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THE PLANT DISEASE REPORTER

Issued By

THE PLANT DISEASE SURVEY

Division of Mycology and Disease Survey

BUREAU OF PLANT INDUSTRY, SOILS, AND AGRICULTURAL ENGINEERING

AGRICULTURAL RESEARCH ADMINISTRATION

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The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Division of Mycology and Disease Survey serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

THE PLANT DISEASE REPORTER

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THE PLANT DISEASE SURVEY
DIVISION OF MYCOLOGY AND DISEASE SURVEY

Plant Industry Station
Beltsville, Maryland

Volume 37
April 15, 1953
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PLANT DISEASE LOSS ESTIMATES: FALSE VS. TRUE

Paul R. Miller

In June 1951 the Bureau of Agricultural Economics published Statistical Bulletin No. 99, "Statistics on Cotton and Related Data" (processed). The data includes estimates on percentage reduction from full yield caused by cotton diseases and covers a period of some 40 years, 1909 to 1949 inclusive. Losses are given for individual cotton States and for the country's production as a whole, compiled as Tables 52-65, pages 67-80. The average losses as given in these estimates are so low as to make plant diseases appear to be a wholly negligible factor in the production of cotton, whereas plant pathologists, and anyone else who has studied the whole situation thoroughly, realize only too well that diseases constitute one of the chief production problems and would be even more important if serious attention had not been given to their cause and control.

In contrast to this off-hand treatment of plant diseases, losses due to insects appear to have been given much more careful consideration and agree closely with estimates made by entomologists.

Not only are the disease loss estimates in "Statistics on Cotton" minute in comparison with real losses, but for the most part they are also monotonously the same[1]. From one year to another and between different regions there are only slight variations. This in itself is sufficient to bring the estimates under suspicion to anyone who knows anything about plant diseases. The effects of geographical and seasonal differences on disease incidence were evidently unknown to, or wholly disregarded by, the estimators. Moreover, even the small variations that do appear in their estimates do not correlate with estimates from other sources.

On the other hand, although the estimates give a wholly inadequate impression of the place of plant diseases in cotton production, they do recognize that plant diseases are part of the

Table 1. Percentages reduction from full yield per acre of cotton, by plant diseases, United States, 1917-1939 inclusive.

Comparison between estimates given in "Statistics on Cotton", BAE Stat. Bul. 99, 1951, Table 52, p. 67 and estimates furnished by State plant pathologists to the Plant Disease Survey, BPISAE, published in "Crop Loss Estimates" for the years indicated.

Year	Percentage loss: BAE Table 52	Percentage loss: Plant Disease Survey	Year	Percentage loss: BAE Table 52	Percentage loss: Plant Disease Survey
1917	1.3	14.5	1929	2.3	14.
1918	2.0	15.6	1930	1.7	9.9
1919	1.3	13.6	1931	2.0	15.3
1920	1.1	13.4	1932	3.2	18.
1921	.9	15.8	1933	2.3	21.7
1922	.8	9.2	1934	1.9	11.5
1923	.7	19.5	1935	2.2	17.3
1924	.8	12.6	1936	2.2	14.8
1925	.7	9.1	1937	2.2	26.1
1926	2.1	14.9	1938	1.9	14.8
1927	1.5	15.2	1939	1.8	14.5
1928	1.9	17.2			

[1]For a period of four years the writer spent full time traveling throughout the entire cotton belt conducting a cooperative seedling and boll disease survey. The most impressive observation made during these surveys was the great variation and fluctuation in the amount of disease from one area to another and from one year to another. It seems almost incredible that anyone with experience in estimating the effect of hazards upon cotton production should treat the factors of weather, insects, and plant diseases on such different bases. The variation in occurrence and severity that characterizes all three is evidently taken into account in estimating the first two, but not at all for plant diseases.

Table 2. Percentage reduction from full yield of cotton by plant diseases, 1920-1939 inclusive. Comparison between estimates given in "Statistics on Cotton", BAE Stat. Bul. 99, 1951, Tables 53 to 65, pp. 69-80 inclusive, and estimates furnished by State plant pathologists to the Plant Disease Survey, BPISAE, published in "Crop Loss Estimates" for the years indicated.

State	BAE Estimates[a]	PDS Estimates	
	Percentage loss[b]	Number of years[c]	Percentage loss[d]
Alabama	2.0	6	10.
Arizona[e]		11	13.8
Arkansas	1.5	19	11.4
California[e]		1	3.
Florida	1.8	5	11.6
Georgia	1.6	14	11.8
Louisiana	1.5	18	14.2
Mississippi	1.5	11	11.
Missouri	1.4	6	3.2
Oklahoma	.5	9	17.1
New Mexico[e]		3	10.1
North Carolina	1.7	19	19.4
South Carolina	1.7	14	10.4
Tennessee	1.7	13	10.
Texas	2.2	19	19.9
Virginia	1.7	18	7.6

[a] All for the whole 20 years.
[b] Simple averages of figures given in cited tables.
[c] Number of years for which estimates are available. Lacking estimates do not mean absence of loss, but only that for some reason it was not possible to make an estimate that year.
[d] The averages are simple averages of percentage losses reported for the number of years indicated. Weighting the averages by production would probably give figures differing not more than ± 1 or 2 percent.
[e] Not included in the BAE tables.

situation and should be included with other factors affecting yield. Perhaps the surprising feature is that the uninformed sources of the estimates gave plant disease even this much acknowledgment. Loss appraisal on an adequate basis is, certainly, a difficult task. Plant pathologists themselves have not given systematic attention to loss estimates except for one short period.

The only compilation of reliable information available to refute the erroneous impression of cotton disease losses as given by the BAE is the Plant Disease Survey's Crop Loss Estimates. These estimates were issued for only about twenty years, from 1917 to 1939, after which they were discontinued for various reasons. Although they cover a relatively short time, and are admittedly estimates and not exact measurements, the Plant Disease Survey's estimates still can serve as a standard because they present the opinions of persons who could use authentic knowledge about the subject as a basis for realistic appraisal. The estimates do not exaggerate losses; indeed, as understanding of overall disease effects increases, they seem on the whole to be very conservative with estimated losses smaller than the actual losses.

To demonstrate the disparity between the BAE estimates based on reports from untrained observers, and the Plant Disease Survey estimates prepared by cotton pathologists, we have compiled the accompanying tables, 1 to 3.

The BAE estimates have no possible standing when the facts are known, but the manner of their presentation gives them an appearance of authenticity. It is not inconceivable that

Table 3. Percentage reduction from full yield per acre of cotton by plant diseases, in three representative cotton-producing States, 1919-1939 inc. Comparison between estimates given in "Statistics on Cotton", BAE Stat. Bul. 99, 1951, Table 54 p. 69, Table 60 p. 75, Table 64 p. 79 and estimates furnished by State plant pathologists to the Plant Disease Survey, BPISAE, published in "Crop Loss Estimates" for the years indicated.

Year	Percentage loss					
	Arkansas		North Carolina		Texas	
	BAE	PDS	BAE	PDS	BAE	PDS
1919	2	8	2	15.	1	14.
1920	2	17.	2	24.	1	12.1
1921	1	13.	2	14.	1	27.
1922	1	11.5	1	-[a]	1	-[a]
1923	1	18.	1	14.	1	27.
1924	1	15.5	1	10.	1	16.
1925	1	13.	1	7.	1	11.
1926	0	11.5	1	8.8	4	28.
1927	1	9.5	2	8.3	2	21.
1928	2	8.	1	9.	2	17.
1929	1	10.	2	8.	3	23.
1930	1	4.5	2	9.	2	15.5
1931	1	9.	2	11.	3	18.5
1932	3	9.	2	10.	4	23.6
1933	2	11.	2	11.	3	26.1
1934	2	11.	2	24.	2	12.
1935	2	10.	2	20.	3	24.1
1936	2	15.	2	27.	3	18.5
1937	2	-[a]	2	38.	3	28.
1938	2	9.	3	40.5	2	8.8
1939	2	10.	2	26.	2	11.8

[a] Loss estimate not available for this year.

under some circumstances they could have unfortunate influence in cotton research. It may be said in rebuttal that these or any estimates should always be considered in the light of the way in which they are obtained and the purposes to which they are applicable. In "Statistics on Cotton", however, no statement is given as to the manner of obtaining the estimates; they are put forth without explanation surrounded by other tables on yield, costs, etc., as part of an authoritative source of statistical information on all phases of cotton production. The size of the Bulletin, 410 pages filled with all sorts of tables, is impressive in itself. Persons without background for critical judgment will be inclined to accept it at face value. The very fact that practically all of the contents of the Bulletin can confidently be accepted without question reinforces the influence of this very glaring discrepancy.

Publication of these apparently authoritative but actually completely erroneous and wholly inadequate estimates was a matter of great concern to the Plant Disease Survey, which from the time of its founding has been interested in plant disease loss appraisal, and to cotton pathologists, who recognized the possible consequences to cotton research. Dr. John T. Presley, of the Division of Cotton and Other Fiber Crops and Diseases, joined with the Survey in the immediate preparation of a critical report to the chief of the Bureau of Plant Industry, Soils, and Agricultural Engineering, pointing out the implications of the existence of these false statistics in a field of interest to our Bureau. The report was thoroughly documented with comparative tables, maps, charts, and references to published data on cotton disease appraisal, and its evidence could not be controverted. Nevertheless, the criticism was apparently not recognized to be a serious matter by officials of the Bureau of Agricultural Economics to whom it was trans-

mitted for background to prevent similar errors in future compilations.

The fact that estimates so false could be admitted without question into a publication of the nature of "Statistics on Cotton" is clear demonstration that estimates of losses from plant diseases can no longer be considered as of academic interest only, or as a side issue, but that pathologists must take them seriously as a necessary part of plant disease investigation, important in themselves. The point is that since appraisal of the factors in production is obviously incomplete when diseases are left out, some attempt will be made to judge the extent of the disease effect on the crop, and in the absence of reliable information such misleading figures as the BAE estimates will inevitably obtain recognition. The impression that plant diseases are of little or no consequence might easily become an obstacle to research. There is no assurance that disease investigation in other crops will not be subject to the same sort of belittling influence.

Of course it is too late to do anything about the estimates already published, aside from making their unreliability as widely known as possible. For the future, however, a great deal can be done and the Cotton Disease Council has taken steps to see that it is done. The task of assembling statistics on cotton disease losses was assigned to a committee. The results of the first year of the committee's work are given in the table published on page 176 in this issue, on estimated losses from cotton diseases in 1952.

It is exceedingly interesting to note that the estimators undertook their task without reference to any existing previous estimates of losses from cotton diseases. In spite of this wholly new start, however, the estimates they arrived at are of the same general magnitude as the earlier ones of the Plant Disease Survey, and the evidence for the reliability of both series is thus greatly strengthened.

Obviously, if loss estimates are to be made, they should be carefully considered on the basis of all available facts by persons who are competent to evaluate the data. Moreover, the availability of authentic estimates must be brought to the attention of every person or organization who has use for such information. Finally, the estimates should be current. False estimates can be avoided only by making reliable, up-to-date figures completely available.

DIVISION OF MYCOLOGY AND DISEASE SURVEY

REDUCTION IN YIELD OF COTTON CAUSED BY DISEASES IN 1952

Compiled by the Cotton Disease Council's Committee on Disease Losses, Philip J. Leyendecker, Chairman.

The accompanying tabulated summary of estimated losses from cotton diseases in 1952 was prepared by the Committee on Disease Losses from estimates received from 48 specialists across the cotton belt. When a number of loss estimates were received from a State, an average was calculated and recorded under the appropriate disease column, therefore, the final disease percentages may vary somewhat from those reported by one individual. Otherwise, the figures were tabulated without revision. In computing bales lost, full yield was calculated for each State before the reduction due to diseases was determined.

It is recognized that the percentages as reported are estimates and as estimates may not represent the exact disease complex, however, the Committee feels that a definite contribution to our knowledge of the importance of cotton diseases on a belt-wide basis has been made.

The list of cooperators follows.

1. Dr. A. L. Smith, Alabama Agricultural Experiment Station, Auburn, Alabama
2. Mr. Bob Peebles, U. S. Field Station, Sacaton, Arizona
3. Mr. E. H. Pressley, University of Arizona, Tucson, Arizona
4. Dr. Harold Reynolds, U. S. Field Station, Sacaton, Arizona
5. Dr. R. B. Streets, University of Arizona, Tucson, Arizona
6. Dr. C. A. Moosberg, Cotton Branch Experiment Station, Marianna, Arkansas
7. Mr. Harlan E. Smith, University of Arkansas, Fayetteville, Arkansas
8. Dr. J. O. Ware, University of Arkansas, Fayetteville, Arkansas
9. Dr. V. H. Young, University of Arkansas, Fayetteville, Arkansas
10. Mr. George Harrison, U. S. Cotton Field Station, Shafter, California
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12. Mr. W. W. Ballard, Georgia Agricultural Experiment Station, Griffin, Georgia
13. Dr. B. B. Higgins, Georgia Agricultural Experiment Station, Griffin, Georgia
14. Dr. J. H. Miller, University of Georgia, Athens, Georgia
15. Dr. John H. Turner, Jr., U. S. Cotton Field Station, Shafter, California
16. Dr. S. J. P. Chilton, Louisiana Agricultural Experiment Station, Baton Rouge 3, Louisiana
17. Dr. D. C. Neal, Louisiana Agricultural Experiment Station, Baton Rouge 3, Louisiana
18. Dr. John Presley, U. S. Department of Agriculture, Beltsville, Maryland
19. Dr. Paul Miller, U. S. Department of Agriculture, Beltsville, Maryland
20. Mr. J. B. Dick, Mississippi Delta Branch Experiment Station, Stoneville, Mississippi
21. Dr. A. B. Wiles, Mississippi State College, State College, Mississippi
22. Dr. E. M. Brown, University of Missouri, Columbia, Missouri
23. Mr. W. J. Murphy, Missouri Agricultural Extension Service, Columbia, Missouri
24. Dr. H. R. Garriss, Extension Plant Pathologist, Raleigh, North Carolina
25. Dr. S. G. Lehman, North Carolina Experiment Station, Raleigh, North Carolina
26. Mr. L. A. Brinkerhoff, Oklahoma A & M College, Stillwater, Oklahoma
27. Dr. John Greene, Oklahoma A & M College, Stillwater, Oklahoma
28. Dr. C. H. Arndt, Clemson Agricultural Experiment Station, Clemson, South Carolina
29. Dr. Hoyt Rogers, Coker Pedigree Seed Company, Hartsville, South Carolina
30. Mr. J. M. Epps, West Tennessee Agricultural Experiment Station, Jackson, Tennessee
31. Mr. R. P. Mullett, University of Tennessee, Knoxville 7, Tennessee
32. Mr. D. M. Simpson, University of Tennessee, Knoxville 16, Tennessee
33. Mr. Luther Bird, Texas A & M College, College Station, Texas
34. Mr. E. D. Cook, Texas Agricultural Experiment Station, Temple, Texas
35. Mr. Fred C. Elliott, Agronomy Department, Texas A & M College, College Station, Texas
36. Mr. Charlie Fisher, Texas Agricultural Experiment Station, Spur, Texas
37. Dr. G. H. Godfrey, Texas Agricultural Experiment Station, Weslaco, Texas
38. Mr. Jack Hubbard, Texas Experiment Sub-Station No. 15, Weslaco, Texas
39. Mr. Don Jones, Texas Experiment Sub-Station No. 8, Lubbock, Texas

ESTIMATED PERCENTAGES OF REDUCTION IN 1952 COTTON YIELD CAUSED BY DISEASES[a]

Diseases	Ariz.	N. Mex.	Tex.	Okla.	Mo.	Ark.	La.	Miss.	Ala.	Ga.	S.C.	N.C.	Tenn.	Total bales lost
ANTHRACNOSE BOLL ROT														
Glomerella gossypii	0	0	Tr	Tr	1.0	.3	1.0	.25	2.0	.7	.75	.5	.4	63,171
BACTERIAL BLIGHT														
Xanthomonas malvacearum	.25	.5	4.6	.5	1.0	1.0	.5	.25	.5	.7	2.5	1.5	.4	275,760
FUSARIUM WILT														
F. vasinfectum	0	0	Tr	Tr	2.0	1.5	2.0	2.0	1.0	3.0	2.5	2.0	1.25	163,518
VERTICILLIUM WILT														
V. albo-atrum	1.7	3.4	.01	Tr	1.0	Tr	.2	.5	0	0	0	.2	1.75	61,277
ROOT KNOT														
Meloidogyne sp.	2.5	.25	Tr	1.0	1.0	1.0	1.5	.75	3.0	3.0	2.25	5.0	.4	188,225
ROOT ROT														
Phymatotrichum omnivorum	2.75	.05	2.5	.5	0	Tr	Tr	0	0	0	0	0	0	137,865
SEEDLING DISEASES														
Rhizoctonia, etc.	4.5	.15	2.5	7.0	4.0	2.0	2.0	2.0	2.0	4.5	12.5	2.5	2.75	500,457
ASCOCHYTA BLIGHT														
A. gossypii	0	0	Tr	0	0	0	0	0	0	2.0	.25	.1	.05	21,520
BOLL ROTS														
Rhizopus, etc.	.6	Tr	.38	2.5	4.5	Tr	1.0	.25	5.0	4.5	4.25	3.0	.25	199,620
DEFICIENCY DISEASES														
Potash, magnesium, etc.	0	.15	.22	2.0	0	5.0	2.5	.5	2.0	2.6	1.5	2.0	3.0	218,900
OTHERS	.25	.15	0	0	0	5.0	.3	0	0	1.0	4.0	.3	.25	135,464
TOTAL PERCENT LOSS	12.55	4.65	10.21	13.5	10.0	15.8	11.0	6.5	15.5	20.0	30.5	17.1	10.5	
TOTAL BALES LOST	145,078	15,857	426,370	40,635	42,850	248,692	92,730	131,040	163,215	131,200	289,750	115,596	73,290	1,966,303
TOTAL YIELD IN BALES[b]	1,010,000	325,000	3,750,000	260,000	385,000	1,325,000	750,000	1,885,000	890,000	725,000	660,000	560,000	625,000	15,038,000

[a]California (total production 1,825,000 bales) is omitted because only local estimates were available.
[b]Bureau of Agricultural Economics, December 1, 1952

40. Dr. Harold B. Loden, Box 1632, Plainview, Texas
41. Mr. Dow Porter, Texas Agricultural Experiment Station, Greenville, Texas
42. Mr. Roy Quimby, Texas Agricultural Experiment Station, Chillicothe, Texas
43. Mr. L. L. Ray, Texas Experiment Sub-Station No. 8, Lubbock, Texas
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48. Dr. L. M. Blank, New Mexico College of A & M A, State College, New Mexico
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50. Mr. Roy Nakayama, New Mexico College of A & M A, State College, New Mexico
51. Dr. Philip J. Leyendecker, New Mexico College of A & M A, State College, New Mexico

The Committee wishes to thank everyone who participated in the survey.

COMMITTEE ON COTTON DISEASE LOSSES
Philip J. Leyendecker, Chairman;
A. L. Smith,
Leonard Lett,
S. G. Lehman

TEMPERATURE-PATHOGENICITY RELATIONSHIPS IN RHIZOCTONIA SOLANI ON COTTON

Jack C. Schwegmann

While conducting tests in the greenhouse on damping-off of cotton, using an isolate of Rhizoctonia solani from that host, it was noted that at low temperatures, high percentages of damping-off were obtained, whereas at high temperatures, little damping-off occurred. The behavior of this isolate was in accord with observations of severe disease development in the field during periods when low temperatures prevailed. During the winter months greenhouse tests were carried out without difficulty since maximum temperatures were thermostatically controlled. With the arrival of spring, however, maximum temperatures became difficult to control and the incidence of damping-off induced by the isolate used began to decline. With the onset of high summer temperatures, damping-off by this isolate was almost completely suppressed. Loss of pathogenicity was not attributed to a change in the pathogen, since small scale tests with the isolate showed that it was still capable of causing severe damping-off when temperatures did not exceed 18° C.

Table 1. Pathogenicity of isolates of Rhizoctonia solani from cotton under warm temperatures (25° to 30° C.).

Isolate	Average number of plants		
	Emerged from 20 seed	Damped-off (no recovery)	Infected (dead and surviving)
Control	18.7	0.0	0.0
N1D	17.0	0.3	13.7
N2	18.7	6.0	16.0
H1	16.0	7.3	16.0
N3	16.3	15.3	15.7
H2	18.0	13.7	15.3
R1	19.3	15.7	18.3
LSD (P05)	2.0	2.3	3.8
LSD (P01)	2.8	3.2	5.3

Since high temperatures persist for a period of several months in Louisiana, and since no large scale, low temperature facilities were available, it seemed impossible to continue the greenhouse tests during the summer months. In an attempt to circumvent this difficulty, isolates from cotton were obtained and screened to determine whether or not one having more tolerance to high temperature might be found. The screening test was designed so that all conditions other than temperature were favorable for damping-off. Oat cultures of the isolates were added to sterile soil in six-inch clay pots, three pots for each isolate with three non-infested pots of soil serving as controls. Twenty-acid-delinted, Ceresan-M treated seed were planted in each pot of soil. All pots were placed in a humidity chamber, which passed diffuse light, and watered daily for the duration of the test. The test was conducted during June of 1952, when day-time temperatures never failed to reach 30° C. Night temperatures were thermostatically controlled to a minimum of 25° C. The results of this test, presented in Table 1, indicated that definite differences existed in temperature tolerances of the several isolates tested. As the data show, several isolates caused severe injury under the test conditions. This seemed significant since these isolates, known to occur naturally on cotton, appeared to be capable of severely parasitizing cotton seedlings under conditions markedly different from those associated with the disease in the field. It is also interesting to note that all isolates tested appeared to be capable of infecting cotton seedlings under the conditions of the experiment. The test was repeated with similar results. Isolate "R1", which was arbitrarily selected for continuation of the study, consistently produced high percentages of damping-off throughout the summer of 1952.

DEPARTMENT OF BOTANY, BACTERIOLOGY AND PLANT PATHOLOGY, LOUISIANA STATE UNIVERSITY

COLD INJURY TO COTTON SEEDLINGS IN ALABAMA IN 1952

Albert L. Smith, Coyt Wilson, and Henry S. Ward[1, 2]

Extensive loss of stand and replanting of cotton were reported from southeastern and mid-southern States in 1952. Rhizoctonia blight (R. solani), unfavorable weather and pre-emergence chemical damage were the most often mentioned causes of stand losses. In Alabama, Rhizoctonia blight was more destructive than observed for the past several years. However, loss of stand from Rhizoctonia was in most instances not sufficient to cause replanting except where original stands were already marginal. Seedling losses were sufficiently serious to require replanting about 20 percent of the crop in several counties of the Sand Mountain area of northeastern Alabama. Damage in this area was attributed largely to a freak period of unfavorable low soil and air temperature, strong wind, sunshine, and excessive water loss from seedlings.

The maximum and minimum daily temperatures for the period May 5 to May 17 recorded at the Sand Mountain Substation, Crossville are shown in Table 1. The maximum daily temperatures from May 5 to May 9 varied from 87° to 91° F, and are somewhat higher than normal for this locality and season of the year. On the morning of May 10 there was a .60-inch rain accompanied by strong west winds. This initiated a period of low temperatures, strong west wind, and clear weather that persisted through May 14. At this time cotton plants were in the cotyledon stage or beginning the formation of the first true leaves. Perhaps most of the injury occurred on May 11 as symptoms were first noticed on May 12. No further direct damage was observed after the return of more favorable temperatures on May 15.

Table 1. Maximum and minimum temperature, rainfall and observations on wind from May 5 to May 17 at the Sand Mountain Substation, Crossville, Alabama. 1952.

Date	Air temperatures		Rainfall	Wind
	Maximum	Minimum		
	Degrees F.	Degrees F.	Inches	
May 5	91	50		
6	90	74		
7	90	58	.15	
8	88	69		
9	87	74		
10	79	60	.60	Beginning 10 A. M. strong from west
11	69	49		Strong from west
12	69	45	a	" " "
13	70	41		" " "
14	77	40		" " "
15	85	60		
16	83	58		
17	85	56		

[a] Symptoms of cold injury were quite noticeable May 12.

[1] Acknowledgement is made to S. E. Gissendanner, Superintendent of the Sand Mountain Substation, Crossville, Alabama, for calling attention to this problem and for supplying the weather records shown in Table 1.

[2] Pathologist, United States Department of Agriculture, Division of Cotton and Other Fiber Crops and Diseases; Assistant Dean School of Agriculture and Assistant Director of Experiment Station; and Associate Professor and Associate Botanist, Alabama Polytechnic Institute, Agricultural Experiment Station, respectively.

There were scattered areas in fields in which damage occurred ranging from little to almost complete loss of stands. The most striking symptom in these areas at the time of examination on May 15 was the bare stems of seedlings from which the cotyledons, terminal bud, and about 1/2 to 1 inch of the upper stem had disappeared. The stem portions remaining were green and appeared healthy except for the tip-end from which the dead tissue had broken off. Marginal to these areas of most severe damage, many plants still retained the brown killed upper parts. Other plants showed varying degrees of leaf and bud injury. Recently injured buds and young leaves were blackened. Cotyledons showed typical bleached sunscald spots between the veins. The tissue was dried out and whitened in amounts varying from small spots to areas involving most of the leaf.

The effect of wind was evident in rows where plants were thickly planted and clumped together in bunches. Plants on the west side were damaged most; plants protected by others showed less injury; those on the east side of a thick clump might show little or no injury. Stem injury from the tip to the soil line on the west side was common in portions of fields. This would suggest that sand blast may have had a part in producing symptoms, although injuries on cotyledons were not considered typical for sand-blast damage. In general the effect appeared to be primarily from dessication rather than mechanical abrasion. Cotton that emerged thickly enough to provide protection to companion plants did not suffer loss of stand. In a field planting of precision-placed seed in which plants were spaced singly in a flat seedbed with rows running north and south, the loss of seedlings was from 80 to 90 percent.

It would appear that death and injury of the cotton seedlings by dessication was a result of water loss exceeding water absorption. Loss of water was mainly by epidermal transpiration with stomatal transpiration playing a minor role. The clear sunny atmospheric conditions caused the epidermal cells to have temperatures higher than the air temperatures. The cool air passing over the epidermal cells caused rapid loss of water because of high wind velocity and a rather steep vapor pressure gradient (warm evaporating surface plus cool dry air over the evaporating surface). The steep vapor pressure gradient and high wind velocities caused a rapid loss of water which was not balanced by water absorption. Water absorption was retarded because of low soil temperatures. Arndt (1) has shown cotton roots have a marked reduction in water absorption when soil temperatures are lowered to 18° C. The data in Table 1 seemed to indicate that cool soil temperatures prevailed during the period when the cotton seedlings were injured and killed.

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COOPERATIVE INVESTIGATIONS BETWEEN DEPARTMENTS OF AGRONOMY AND SOILS AND BOTANY AND PATHOLOGY, AGRICULTURAL EXPERIMENT STATION, ALABAMA POLYTECHNIC INSTITUTE: AND UNITED STATES DEPARTMENT OF AGRICULTURE, BUREAU OF PLANT INDUSTRY, SOILS AND AGRICULTURAL ENGINEERING, DIVISION OF COTTON AND OTHER FIBER CROPS AND DISEASES

LOWLAND RICE FARMING, A POSSIBLE CULTURAL CONTROL FOR SCLEROTINIA SCLEROTIORUM IN THE EVERGLADES[1]

Warren N. Stoner and W. D. Moore[2]

Sclerotinia sclerotiorum (Lib.) D By. has been known to cause economic losses in several crops in Florida for many years, but it was not until 1948 that it became a serious problem on the mucklands surrounding Lake Okeechobee. In January and February of that year Stoddard (6) reported losses, due to infection by this fungus, of several acres of celery near Belle Glade, and approximately 50 percent of a 500-acre lettuce planting near Moore Haven. A subsequent survey of the area showed light infections on all farms visited. These observations led to the initiation of a research program to determine suitable control measures for sclerotiniose.

Brooks (1) in 1938 reported that flooding experiments at Sarasota indicated some control of the disease by destroying the sclerotia in the soil. In 1939 (2) he reported a great reduction in apothecial development in plots of a flooding experiment, and stated that observations on the 1938-39 celery crop indicated that commercial fields flooded for six to eight weeks during May, June, and July of 1938 had less than 1 percent infection while others not flooded or inadequately flooded had as high as 10 percent infection.

Moore (4) in 1949 reported the results of laboratory and field studies of flooding as a means of destroying the sclerotia of Sclerotinia sclerotiorum and pointed out that the sclerotia decayed completely after 23 to 45 days of flooding. In Moore's investigations decay was equally rapid under flood, regardless of depth of sclerotial burial in the soil, and alternate flooding and draining at three-day intervals was as effective as continuous flooding. These trials also showed that sclerotia decayed slowly and incompletely when subjected only to prevailing rainfall in nonflooded fields.

Stoddard (7) in 1949 reported the results of a series of static flooding (pumping and holding water at a given level) experiments to rot the sclerotia in the soil. Under the conditions of the experiments, the sclerotia were decomposed after 35 days of continuous flooding to a depth of 10 inches. One entire farm that had large numbers of sclerotia in the soil was flooded for 34 days during the summer of 1948, and though apothecia were found on adjacent unflooded land in the winter of 1949 no infections were observed in susceptible crops grown on the summer flooded land.

Static flooding showed promise of giving good cultural control, but in view of the sporadic occurrence of sclerotiniose in the area the practice did not seem economically feasible as a standard annual control measure. Investigations prior to 1949 indicated that a partial control was possible by using 1000 to 2000 pounds of cyanamid per acre each year, but this too was uneconomical since control was not entirely effective and the nitrogen liberated by the cyanamid on decomposition was not needed on the mucklands. All attempts to control the disease by chemical spraying had failed.

From the results of investigations prior to the summer of 1949, it seemed that flooding still offered a good possibility for control if a way could be found to make the procedure pay for itself. An obvious crop to try was rice since it grows well under flooding and produces a cash crop. Cost of static flooding of typical vegetable land in the Everglades for the six-week period necessary for control will average $2.50 per acre[3]. A rice crop would be flooded for approximately 90 days and flooding would therefore cost about twice as much as would static flooding, but a worthwhile net profit could reasonably be expected. In 1952 the market price for short grain rough rice was $6.25 to $6.35 per 100 pounds and the average yield per acre in the South was 2,240 pounds (8). Thus this past year a grower could have grossed $140 per acre and could have expected a net return of perhaps $50.

In addition to being a cash crop, rice also seemed to have other possible advantages for the area. Flooding would control certain weeds, and perhaps partly control pests and other soil-borne organisms besides Sclerotinia. On the mucklands, drainage and accompanying oxi-

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[3]Cost figures furnished by A.L. Craig, Hydraulic Engineer, Soil Conservation Service, U.S.D.A., are based on water handling alone and he assumed a one to two foot water table with fields not more than one foot out of level. Initial cost of diking, ditch blocking and setting of pumps would be $5.00 per acre, but this cost would drop to 50 cents per acre in succeeding years. Depreciation of pumps is included in figures given. Estimates were derived from 1952 costs.

dation are responsible for the loss of about one-tenth of a foot of soil annually (5). Rice culture would maintain a high water table for a considerable time in summer and should be effective in counteracting some of this subsidence. The production of a small grain would do much to stabilize the agriculture of the area, and mill byproducts would furnish much needed supplementary feed for cattle. Little additional fertilizer would be necessary for the crop, since residuals from vegetable growing are sufficiently high to supply the requirements of rice. The crop would be grown in the off-season for vegetables and should help to stabilize some migratory labor. Finally, a grower could perhaps use the second-cut crop for pasture if winter conditions warranted or let it mature for grain in the spring. Thus rice could be an ideal crop even in a three, or four, year rotation in the Everglades. The authors discussed these possibilities of rice in October 1949 and cooperative experiments were started in the spring of 1950 to determine whether lowland rice culture was as effective as static flooding in decomposing the sclerotia of S. sclerotiorum and whether lowland rice could be grown on the organic soils of the area.

PILOT EXPERIMENTS -- Two paddies 30 feet square were located on Everglades muck soil 100 yards apart in the same field at the Everglades Experiment Station. Dikes were erected and one plot, designated as paddy A, was fitted with a flume and floodgate for controlled flooding. The other, paddy B, was only diked since it was to be used for upland rice. The soil in both plots was spaded and leveled and 4.5 pounds of sclerotia were broadcast and raked into each on April 26, 1950. On May 12 five-week-old rice plants, grown in the greenhouse, were set in both paddies in rows one foot apart at one-foot intervals. Overhead irrigation was used until the plants were well established.

Light wooden frames one foot square with plastic screen tacked on one side were used for holding sclerotia in place for the tests. One hundred sclerotia were distributed in the frames and another piece of screen was placed over the top to prevent loss of the sclerotia into the soil. These frames were buried at a 3-inch depth in both paddies. They were removed from each paddy at the intervals indicated in Table 1 for each experiment, and the sclerotia were counted and their condition noted. The sclerotia were rated on the basis of percent decomposition, and on the consistency of the remaining core. Those retaining their size and shape and a firm texture were considered unaffected. Sclerotia with half their original bulk and a rubberoid consistency were rated half-rotted and those consisting of a fragment one-quarter the original size and not soft enough to smash with medium pressure of the thumb and forefinger were rated three-fourths rotted. Sclerotia rotted completely could be identified by their outlines on the screen and the masses of slime. Previous laboratory tests had indicated that sclerotia remain viable until approximately half decomposed.

Flooding of paddy A began on June 10, 1950 and continued until August 15. Except for two different days toward the end of the test, when pump failure allowed the water level to fall, paddy A was flooded with moving water to an average depth of four inches. The floodgate discharge was 9.7 gallons per minute[4]. Paddy B was treated the same as paddy A except that it was not flooded.

On June 9, 1950, eight frames of sclerotia were buried in each paddy. The first sclerotial counts made on June 20 on a frame from each paddy showed that 96 of the 100 in the paddy B were unaffected and four had just begun to decompose. Close examination showed that these four were sclerotial fragments and consequently their coverings were not intact when placed in the screen. Only 41 sclerotia of the 100 taken in the first frame, subjected to ten days of dynamic flooding, in paddy A remained unaffected. This was a large number to be destroyed in view of previous reports of a minimum of 35 days of static flooding necessary for complete decomposition. On June 27, a second set of frames from each paddy was taken for examination. Counts showed 85 of the 100 from paddy B were unaffected while 91 of the 100 from paddy A were completely rotted and the 9 remaining were more than three-fourths-rotted. That is, there were only small cores that were still solid after seventeen days of dynamic flooding. Because of this rapid deterioration five of the last six screens in both paddies were removed and the sclerotia counted the next day. Of the original 500 there were 415 sclerotia unaffected in paddy B, 68 beginning to rot, and 17 completely rotted. The completely rotted sclerotia in this series were believed to be fragments instead of whole sclerotia as was observed in the first frames examined on June 20. Only 25 sclerotia of the 500 taken from paddy A were not completely rotted; sixteen of the 25 were three-fourths-rotted and 9 were one-half rotted.

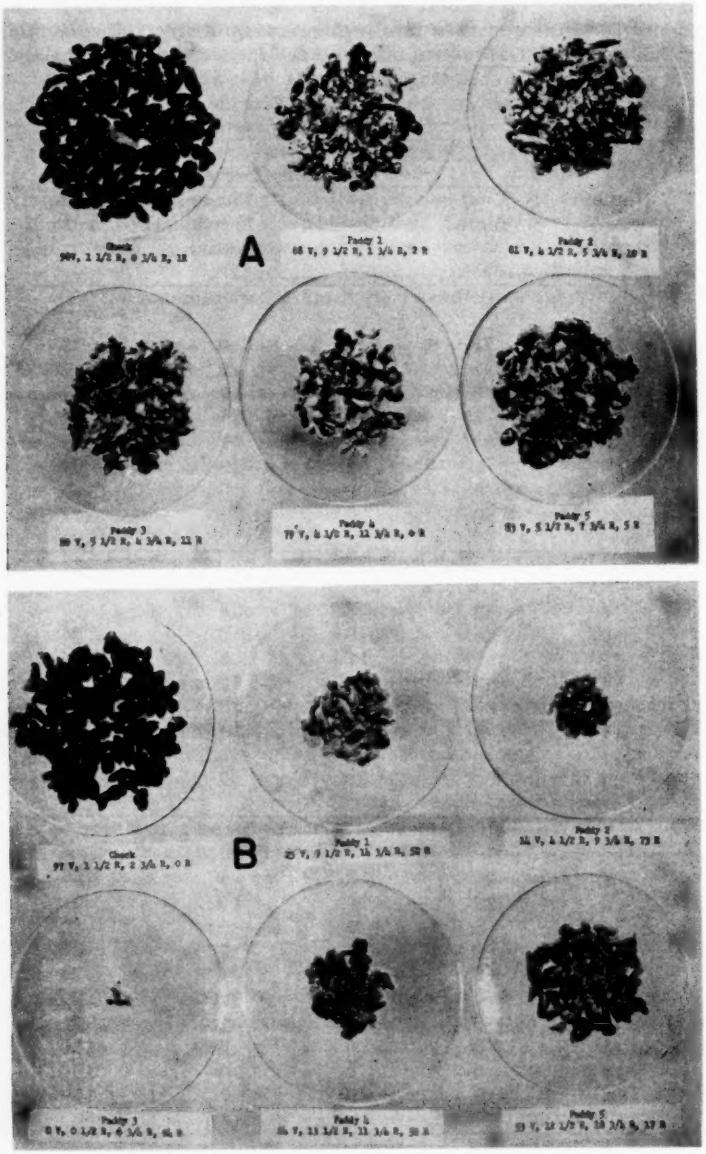
[4]Flow figures derived from data supplied by Kenneth A. Harris, Formerly Assistant Agricultural Engineer, Everglades Experiment Station.

Table 1. Averages of the counts of five replicates containing 100 sclerotia each of Sclerotinia sclerotiorum buried three inches under the soil surface and subjected to circulating flood water of lowland rice culture the indicated number of days. Belle Glade, Florida, 1951.

Date of count	Number days flooded	Number of sclerotia: Unaffected	Half rotted	Three-fourths rotted	Completely rotted
Trial 1, Hillsboro Plantation Experiments					
5-23	8	78	11	0	11
5-26	11	32	40	0	8
5-30	15	8	13	17	62
5-31	16	6	16	17	61
6-2	18	3	4	11	81
6-3	19	1	2	13	84
6-4	20	0	2	5	93
6-5	21	0	0	2	97
Trial 2, Hillsboro Plantation Experiments					
6-13	8	82	5	6	7
6-15	10	69	10	6	15
6-17	12	35	11	9	44
6-19	14	23	8	12	58
6-20	15	17	7	10	66
6-21	16	8	5	8	79
6-22	17	8	4	7	81
6-25	20	6	1	5	87
Hillsboro Commercial Planting Experiment					
8-24	8	20	13	14	53
8-25	9	20	14	15	52
8-26	10	5	5	9	80
8-27	11	2	3	8	87
8-28	12	0	2	4	94
8-29	13	0	2	1	97
8-30	14	0	0	1	99
8-31	15	0	0	0	100
9-1	16	0	0	0	100
9-3	18	0	0	0	100

It was decided to determine, if possible, the comparative viability of the sclerotia taken from the five frames from each paddy on June 28. Twenty-five unaffected sclerotia from paddy B were selected at random, washed three times in distilled water, and plated on potato-dextrose agar. The 16 three-fourths-rotted and the 9 half-rotted sclerotia from paddy A were handled the same way and 25 sclerotia from the original supply were also plated as a check. By July 1, 1950 mycelium was visible on the plates. All of the 25 sclerotia from paddy B had germinated. Four of the nine half-rotted sclerotia from paddy A showed weak germination but none of the 16 three-fourths-rotted or the 25 checks had germinated. Ten days later the checks had germinated normally, but none of the three-fourths-rotted sclerotia produced any growth. Repeated plating of sclerotia three-fourths or more rotted in further trials confirmed that sclerotia in this state of decomposition are not viable.

The last frame of this pilot experiment was removed from the paddies on July 1. The frame from paddy B contained 88 unaffected sclerotia, 6 half-rotted ones, 3 three-fourths-rotted, and



(See page 185 for the legend)

3 completely disintegrated. All sclerotia in the frame from paddy A were rotted. Thus the sclerotia under dynamic flooding were destroyed in 20 days, about half the time necessary for complete disintegration under static flooding.

The rice crop in both paddies was grown to maturity and the stubble removed November 20, 1950. Pascal celery was planted in both plots January 13, 1951, and grown to maturity in an attempt to determine the effectiveness of the kill of the 4.5 pounds of sclerotia worked into the soil in each paddy. Climatic conditions were unfavorable for the development of the fungus and no plant infections or apothecia were observed in either paddy. The same difficulty was encountered with a crop of beans planted November 20, 1951, and a second crop of celery

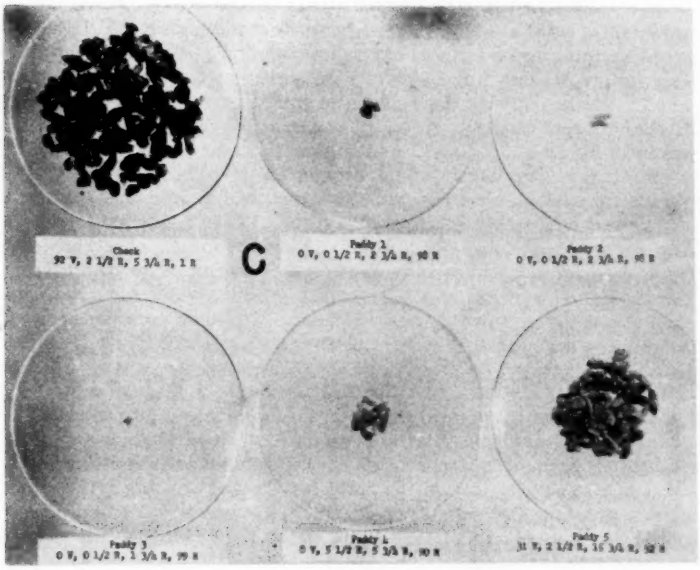


FIGURE 1. Remains of 100 sclerotia of Sclerotinia sclerotiorum removed from each of five plots (paddies) after: A, eight days; B, fourteen days; C, twenty days of flooding under lowland rice.

Condition of sclerotia indicated by: V, unaffected; 1/2 R, half-rotted; 3/4 R, three-fourths rotted; R, completely decomposed. Difficulty was encountered in flooding Paddy 5 completely. This accounts for the consistently better condition of the sclerotia in this replicate throughout the trial. The check in each series was made from separate lots of 100 sclerotia buried in a corn field 200 yards from the flooding trial. Check sclerotia were subject to precipitation moisture only. Photographs by Grant E. Averill.

planted February 12, 1952.

HILLSBORO PLANTATION EXPERIMENTS -- In February of 1951, rice was planted on 160 acres of the Hillsboro plantation near Belle Glade, Florida. Germination was good, but the young plants soon began to die and the planting was abandoned. Experiments were started on the same land by the senior author in April 1951 to determine the cause of this failure. In the paddies set up for these experiments and in cooperative investigations with Green (3) in the summer of 1951 an opportunity was afforded for conducting further trials to determine the effectiveness of dynamic flooding for decomposing the sclerotia of S. sclerotiorum.

In these experiments the sclerotia were handled in frames rated as in the pilot experiments. Eight frames containing 100 sclerotia each were buried in each of five separate paddies on May 9, 1951. This first replicated trial was to be a continuous flooding trial, but cultural operations and unavoidable pump breakdowns caused the flooding to be intermittent. Paddy 5 could not be flooded until after flooding was started in paddies 1 to 4. Consequently the counts of paddy 5 lagged but they did follow the general pattern of the other four. Water was started onto paddies 1 to 4 on May 16 for complete coverage for 24 hours. The water level was dropped on May 17 and then water was applied 12 hours a day for the next three days. On May 21 all five paddies were flooded and maintained under continuous water until the end of the counts. As in the pilot experiments a frame was taken from each paddy for each observation and the number and condition of the sclerotia were noted. The average of the counts and the dates they were made are given in Table 1, under Trial 1, Hillsboro Experiments. This test was completed on June 5 so that, counting the first week of intermittent flooding, the sclerotia were completely decomposed in 20 days.

A second experimental trial similar to the above was started on the Hillsboro Plantation on June 5 and carried to completion under continuous flooding. Counts were started on June 13 and made at two-day intervals until June 19 when daily samplings were started. The test was completed on June 25. Table 1 shows the results of the five replicates of these investigations, under Trial 2, Hillsboro Experiments. Again decomposition of the sclerotia was complete for all practical purposes in 20 days. Paddy 5 was higher than the others and could not be satisfactorily flooded to the three-inch depth. Sclerotia in the frames buried in this paddy did not rot so rapidly as those located in the other four paddies, which accounts for the lower averages given as completely rotted in the closing days of Trial 2, Table 1. In this experiment check screens of sclerotia were buried in a corn field 200 yards from the rice paddies. The sclerotia in one of these check screens were examined each time screens were taken from the flooded paddies. In all cases over 90 percent of the sclerotia in the checks were viable and apparently were in excellent condition for apothecial development. The comparative condition of the sclerotia on three selected dates in this experiment are shown in Figure 1.

HILLSBORO COMMERCIAL PLANTING EXPERIMENTS -- A chance for a field trial was afforded in an 80-acre commercial rice planting on the Hillsboro plantation in the late summer of 1951. Fifty screens were buried in the field August 6. The field was flooded on August 17 and remained so for three days. The water was then removed and flooding was not resumed until August 24. Water was circulating in the field for the rest of this trial. Average sclerotial counts of this trial are given in Table 1 under Hillsboro Commercial Planting Experiment. Even with the loss of four days of circulating flood water the sclerotia were completely rotted in 18 days. There were two fragments of sclerotia left of 500 on August 31 and one of 500 on September 1. All 500 of the sclerotia on September 3 were completely rotted. That is the reason the average figures show complete destruction on these three days.

SUMMARY AND CONCLUSIONS -- Repeated experiments have shown that the sclerotia of Sclerotinia sclerotiorum can be completely rotted in field soil in the Everglades under the cultural practices employed in lowland rice farming during the summer. This decomposition is complete in 20 days in contrast to a minimum of 35 days necessary in static flooding. Observations during the tests indicate that sclerotial fragments or whole sclerotia rot very rapidly when the covering is abraded. The quick thorough destruction of the sclerotia in the field under lowland rice indicates that this economical cultural method of control for sclerotiniose may be fitted into a satisfactory rotational program in the area, since rice may be grown on infested high-value vegetable land in summer.

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EVERGLADES EXPERIMENT STATION, BELLE GLADE, FLORIDA AND UNITED STATES DEPARTMENT OF AGRICUTLURE

A PRELIMINARY TRIAL OF LOWLAND CULTURE RICE IN ROTATION WITH VEGETABLE CROPS AS A MEANS OF REDUCING ROOT-KNOT NEMATODE INFESTATIONS IN THE EVERGLADES[1]

Walter H. Thames, Jr., and Warren N. Stoner[2]

Flooding has often been proposed for the reduction of large populations of root-knot nematodes. Bessey (1) cited the observations of truck crop growers in the Everglades of Florida that crops grown on soils flooded annually for two to six months were almost free of nematode galls. Brown (3) conducted flooding trials on peat soils of King Island, near Stockton, California, to determine the period necessary to provide complete control of root-knot nematodes. He found 12 to 22.5 months to be necessary for eradication. His tests showed that flooding for four months was sufficient to kill the larvae, but eggs remained viable for a much longer period. Tyler (8), and Watson and Goff (9), suggested flooding for the control of root-knot nematodes. In both reports Brown's work in California is cited in support of the recommendations.

Flooding has also been noted by Brooks (2) to be effective in destroying the sclerotia of Sclerotinia sclerotiorum (Lib.) D By. at Sarasota, Florida. Stoddard (6) has reported results obtained by static flooding for control of sclerotiniose disease at Belle Glade, Florida.

The natural features of the truck crop farming area of the Everglades are conducive to the use of flooding as a control measure. The extensive drainage systems installed on farms in the area require little modification to enable growers to maintain selected fields under flooded conditions. The abundance of water from the close of the vegetable-growing season in June until late September is an added advantage.

The prolonged flooding employed in the lowland method of rice culture suggested to the authors the possibility of obtaining an economical control of sclerotiniose disease and a reduction in the population of root-knot nematodes while producing a valuable crop. This paper presents the information obtained on nematode control from a cooperative preliminary trial based on this premise. Results on sclerotiniose disease control are given elsewhere by Stoner and Moore (7).

PROCEDURE AND RESULTS

Two plots (designated A and B), 25 feet square, on well-decomposed Everglades peat, were diked and prepared for the trial. Thirty pounds of chopped roots of beans and squash, heavily infested with the root-knot nematode, Meloidogyne incognita (Kofoid & White)[3], and 4.5 pounds of sclerotia, were spaded into the upper six inches of soil of both plots on April 26, 1950. On May 12 five-weeks-old rice seedlings were transplanted in the plots in rows six inches apart. Both plots were irrigated intermittently with sprinklers until June 10. At this time Plot A was flooded to a depth of four inches. Plot B was grown under upland culture (without flooding) until the rice matured.

Ditch water was pumped into Plot A through a pipe to a flume from which it flowed down on splash boards and onto the west side of the plot. A gate with a sliding panel allowed a constant flow off the plot, from the east side. The rate of flow at this gate was determined to be 9.7 gallons per minute.

Water was maintained on the flooded plot until August 15, with the exception of two periods of 24 hours each in which pump failure permitted the water level to fall to surface level. The total period of inundation was 66 days. The rice in the two plots matured normally, with the lowland plot, A, bearing more grain than the upland plot, B. The rice stubble in both plots was pulled by hand on November 20 in order to prepare the land for the next crop as soon as possible. The soil from the stubble was shaken back onto the plots.

Pascal celery was transplanted to the plots on January 13, 1951 and grown to maturity according to the usual practice of the area. On May 13, ten plants were selected at random from every other row of the two plots and rated for severity of nematode infestation by an arbitrary index, in which 0 represented no galls and 4 represented severe galling. The results of these counts are given in Table 1. The marked difference in infestation of the celery from the two

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[2]Assistant Entomologist and Assistant Plant Pathologist respectively, Everglades Experiment Station, Belle Glade, Florida.

[3]Specimens determined by M. W. Allen, Assistant Nematologist, University of California, Berkeley.

Table 1. Root-knot infestation index of first planting after rice. Pascal celery. Rated on a scale in which 0 indicates no gall formation and 4 indicates severe galling. Belle Glade, Florida.

Plot A, Lowland (flooded) Row number					Sample number	Plot B, Upland (not flooded) Row number				
1	3	5	7	9		1	3	5	7	9
1	1	0	1	1	1	3	3	3	1	3
1	1	0	1	1	2	3	2	1	2	3
1	1	0	0	1	3	3	2	1	3	3
1	1	1	1	1	4	2	1	1	2	3
0	1	1	1	0	5	2	3	2	2	1
0	0	1	1	0	6	1	2	3	2	1
0	1	0	1	1	7	2	2	2	2	3
0	1	1	0	1	8	2	2	3	3	3
0	1	1	1	1	9	2	1	2	3	3
1	1	1	1	1	10	2	2	3	2	2
4	9	7	8	8	TOTALS	22	20	21	22	25

Table 2. Root-knot infestation index of second planting after rice. Black Valentine beans. Rated on a scale in which 0 indicates no galls and 4 indicates severe galling. Belle Glade, Florida.

Plot A, Lowland (flooded) Row number					Sample number	Plot B, Upland (not flooded) Row number				
1	3	5	7	9		1	3	5	7	9
1	0	0	0	1	1	0	4	3	4	2
0	0	0	1	0	2	4	3	4	4	2
0	0	0	1	1	3	2	4	4	4	4
1	0	0	3	1	4	0	4	3	4	4
0	1	0	1	2	5	2	4	4	3	2
2	2	1	4	0	6	0	4	3	4	4
0	2	1	1	1	7	3	3	4	2	2
1	2	1	0	1	8	0	4	3	3	4
0	1	1	0	1	9	0	4	4	0	3
0	0	2	0	0	10	3	3	4	0	4
5	8	6	11	8	TOTALS	14	36	36	28	31

plots is illustrated in Figure 1.

Two additional test plantings of vegetables were made to determine how long there would continue to be a difference in infestation on successive crops planted in the two plots. On November 20, 1951, Black Valentine beans were replanted to replace an earlier bean planting destroyed by frost. The roots of these beans were examined on February 12, 1952. The degree of infestation was rated in the same manner as the initial celery planting. From the results of these counts, listed in Table 2, it will be seen that the flooded plot still had a lower infestation than the unflooded. Bean roots pulled from the plots at the time of this count are shown in Figure 2. The bean plants were turned under on February 15.

The third crop after the initial rice planting was again celery; this was transplanted on

Table 3. Root-knot infestation index of third planting after rice. Pascal celery. Rated on a scale in which 0 indicates no galls and 4 indicates severe galling. Belle Glade, Florida.

Plot A, Lowland (flooded) Row number					Sample number	Plot B, Upland (not flooded) Row number				
1	3	5	7	9		1	3	5	7	9
3	4	3	4	4	1	2	3	3	3	3
3	4	3	4	4	2	2	3	4	3	3
3	4	4	4	4	3	3	3	3	4	4
3	4	4	4	4	4	2	3	3	4	4
3	3	4	4	4	5	3	3	3	4	4
4	4	4	4	4	6	3	3	3	3	3
3	4	4	4	4	7	3	3	3	3	4
3	4	4	4	4	8	3	3	3	3	3
3	3	3	4	4	9	3	3	3	3	3
3	3	3	3	4	10	3	3	3	3	3
31	37	36	39	40	TOTAL	27	30	31	33	34

on February 19. Samples were rated for degree of root-knot infestation on June 17. The infestation was found to be equally severe in both plots (See Table 3). Whole plants, typical of the range of root-knot injury in the third crop, are shown in Figure 3.

The above observations indicate that a rice-vegetable rotation may be a practical method of reducing field infestations of root-knot nematodes on peat soils. The influence of at least three factors needs study before the practice can be recommended to growers for limited trial. First, the effect of flooding with free-flowing water, as used in this trial, may be different from the effect of the stagnant pools which might be established if large fields were flooded. Second, the use of water of high pH to flood fields might raise the soil pH in the field to undesirable levels (10). Third, although Tyler (8) lists rice as a plant resistant to the root-knot nematode, Steiner (5) reports that rice suffers severely from root-knot nematodes in the young seedling stage. The parasitic relationship of the different species of root-knot nematodes to the commercial varieties of rice is not clear at present. The nematode with which Steiner was working has not yet been referred to one of the species listed by Chitwood (4) in his revision of the genus Meloidogyne Goeldi. It is possible that the species which Steiner found attacking rice is not the same as the species, Meloidogyne incognita (Kofoid & White), most common in the Southeast. Root-knot nematodes have not been found to be economic pests of rice in the United States.

SUMMARY

The treatment history of the trial may be summarized as follows:

1950	April 26	Chopped infested roots and sclerotia added to the plots.
	May 12	Five weeks old rice seedlings transplanted to the plots.
	June 10	Plot A flooded.
	August 15	Plot A drained after 66 days under flood.
	November 20	Rice stubble removed from plots.
1951	January 13	Transplanted first crop, Pascal celery, on the plots.
	May 13	Celery roots rated for infestation.
	November 20	Planted second crop, Black Valentine beans.
1952	February 12	Roots of bean plants rated for infestation.
	February 19	Transplanted third crop, Pascal celery, on plots.
	June 17	Third crop rated for root-knot infestation.

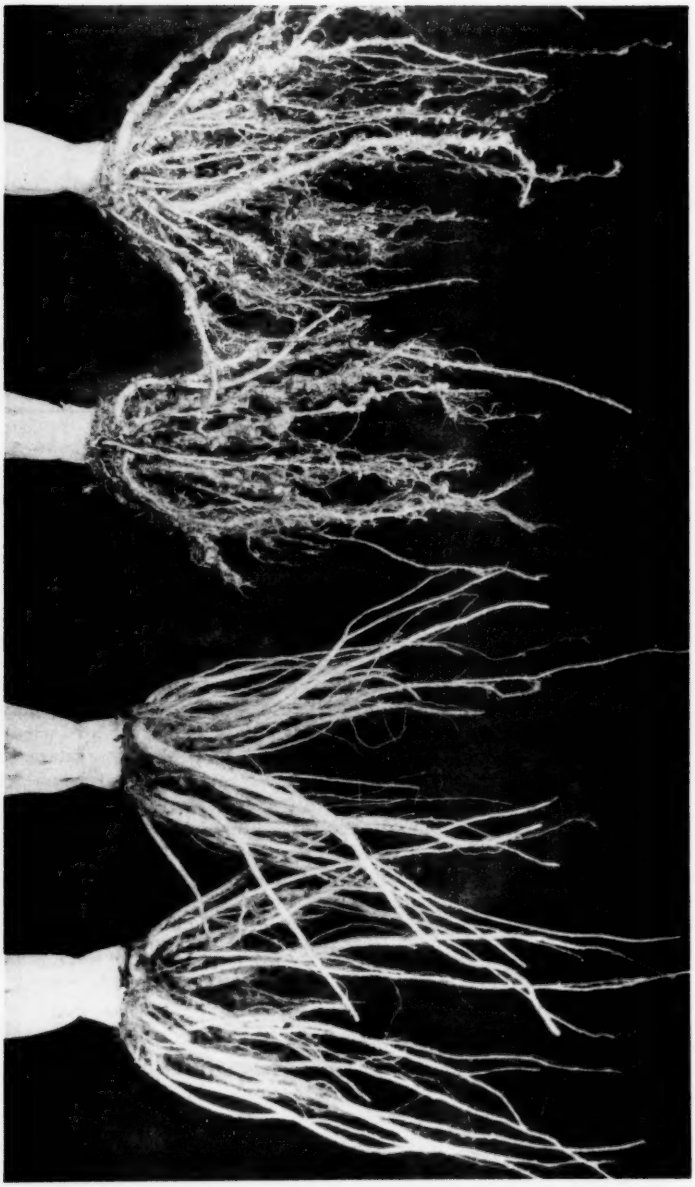

FIGURE 1. Roots of celery grown as the first crop after rice. Plants on left taken from Plot A (flooded), those on right from Plot B (not flooded).

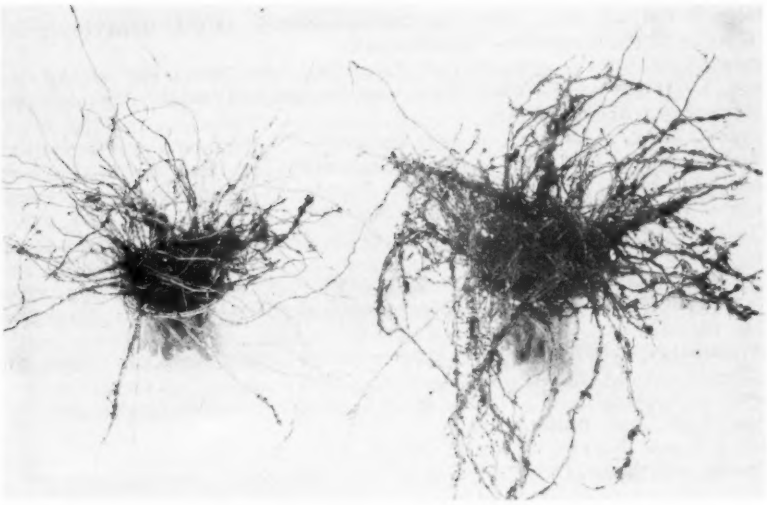

FIGURE 2. Roots of beans grown as second crop after rice. Plants on left from Plot A (flooded), those on right from Plot B (not flooded). Twenty-five randomized plants from each plot were used for this illustration.

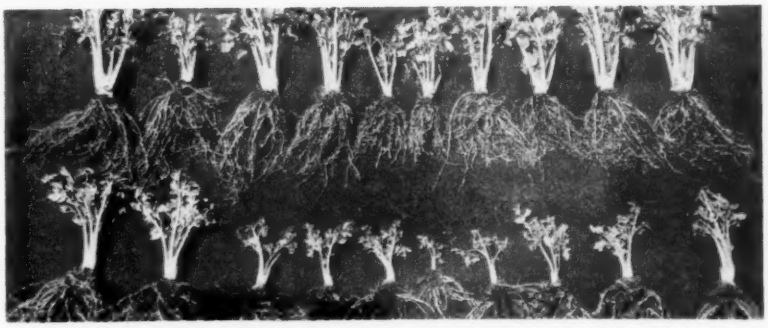

FIGURE 3. Celery plants grown as third crop after rice. Plants in bottom row taken from Plot A (flooded), plants in top row from Plot B (unflooded). Note that infestation is about equal in both plots.

In this preliminary trial, a practical control of root-knot nematodes was obtained. This control permitted the following crop of celery to grow to maturity with only a slight infestation of nematodes. The reduction obtained was still apparent on a second crop planted a year after the rice, but by the third planting the infestation was equally severe in both plots.

ACKNOWLEDGMENTS

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CONTROL OF ROOT-KNOT NEMATODE ON COTTON

D. J. Raski and M. W. Allen

In some areas of the San Joaquin Valley the root-knot nematode, Meloidogyne incognita var. acrita, annually causes damage to a considerable acreage of cotton. The control of this pest in cotton land involves cultural practices such as crop rotation and summer fallow, or the more direct control that can be obtained by the preplanting application of nematocides to the soil. The cultural methods of control have distinct limitations so far as cropping practices are concerned. To achieve control by crop rotation it is necessary to grow a particular sequence of crops in order to reduce nematode populations in the soil prior to the planting of cotton. Alfalfa is the crop most frequently used for this purpose. For effective summer fallow it is necessary that the land be free of plant growth for at least six weeks or two months in the middle of the summer. In addition the land should be ridged up several times for the most thorough drying and heating of the soil. Both of these practices are objectionable to many growers since they may require the planting of less profitable crops or the land must be idle during the best part of the growing season. Soil fumigation, while it is a costly operation, enables the grower to plant even the most susceptible crops on root-knot nematode infested land and at the same time obtain yields that give profit above the cost of the fumigation.

Flat Treatment -- The standard practice for the control of root-knot nematode in the lighter, sandy soils in California is the application of 20 gallons of D-D per acre or 4 to 6 gallons of ethylene dibromide per acre. These fumigants are generally applied by means of a chisel type applicator with the chisels spaced at 12 inches and set to deliver the chemical to a depth of 8 inches in the soil. Since the recommended dosages of the fumigants cannot be safely reduced under most conditions and still obtain effective control of the nematode it is obvious that any reduction in the cost of this type of control with the presently available materials can only be obtained by some variation in the method of application.

Row Treatments -- Spot treatments have been successfully used to control root-knot nematode in such crops as melons where the planting sites are widely separated. These treatments have shown that satisfactory control can be obtained by treating the soil area where it is intended that the roots of the plant will grow. This procedure is possible because the young root-knot nematodes do not move long distances in the soil and plants will make good growth on nematode-infested soil if they can be planted exactly in an area that has been fumigated. This growth is made despite the fact that adjacent soil may be heavily infested with the nematode. Since cotton is a row crop it appears to afford the opportunity of reducing the per acre volume of the fumigant while still allowing the application of an effective dosage of the fumigant to the immediate planting and growing area.

Experimental -- Theoretically it would appear that there is a possibility of reducing the amount of the fumigant by two-thirds in cotton plantings where the rows are spaced about 38 inches apart. The results reported here were obtained from plots established on the ranch of Walter Johnson near Weedpatch, California. The field used for the experimental plots had been planted to cotton in 1950 and 1951 and was known to be heavily infested with root-knot nematode from examination of the cotton crop grown in 1951. Also, in this field the cotton is planted in beds, a practice that would seem to be necessary in order to make sure that plantings subsequent to the fumigation are made in the immediate area of the treatment. The experiment occupied six blocks of 20 rows each, and every replicate consisted of two rows of cotton each approximately 380 feet long.

Three types of treatments were compared in these tests, the standard flat treatment of 20 gallons of D-D per acre and various dosages of D-D applied in the row two weeks before planting and at the time of planting. The row applications were made with one chisel in the center of the bed or two chisels approximately 9 inches apart, 4 1/2 inches on each side from the center of the bed. Depth of application was approximately 13 inches from the top of the bed. This was done to minimize the possible loss of fumigant from the sides of the bed.

The flat treatment was applied on March 15, 1952, the row treatment before planting on March 28 and the row treatment at the time of planting on April 14. The entire test area received the fertilizer treatment made on the adjacent commercial planting. This consisted of 10 tons of manure, 300 pounds of cyanamid and 97 pounds of NH_3 gas per acre. The soil in the experimental area is a light sandy loam and at the time treatments were made was in excel-

Table 1. Average yield of lint cotton per acre from treated and untreated plots, calculated from the number of pounds of seed cotton obtained in two pickings from 380 feet of row in each of four replications per treatment. San Joaquin Valley, California.

Treatment	Bales per acre	Bales increase from treatment	Cost of material*	Estimated value of increase **
	A. Row treatments two weeks prior to planting.			
1 chisel 3.9 gal./acre	2.56	.63	$ 6.43	$ 94.50
1 chisel 6.9 gal./acre	2.62	.69	11.38	103.50
1 chisel 9.5 gal./acre	2.77	.84	15.67	126.00
2 chisels 12.0 gal./acre	3.07	1.14	19.80	171.00
Untreated	1.93	--	--	--
	B. Row treatments at planting time.			
1 chisel 3.4 gal./acre	2.57	.72	5.61	108.00
1 chisel 6.6 gal./acre	2.66	.81	10.89	121.50
2 chisels 6.5 gal./acre	2.89	1.04	10.72	156.00
2 chisels 12.7 gal./acre	2.82	.97	20.95	145.50
Untreated	1.85	--	--	--
	C. Flat treatment four weeks prior to planting.			
20 gal./acre	3.35	1.48	33.00	222.00
Untreated	1.87	--	--	--

* This does not include the cost of application, which varies depending on the size of acreage treated; treatment may also be applied by the grower along with other cultural operations.

** Calculated on the basis of 30¢/lb. lint cotton.

lent seed bed condition. The soil temperatures ranged from 14° to 16° C. and the moisture content was approximately equal to the moisture equivalent, 9.1 percent.

RESULTS

Stand Counts -- Because of the known phytotoxic properties of D-D mixture stand counts were made on May 16 to determine whether the stand of cotton was affected by any of the treatments, particularly those made at the time of planting. Counts were made of the total number of plants in a 100-foot section in each row. The counts were rather variable but did not show

Table 2. Weighted root index and percentage of control based on the intensity of the root infection of 400 plants per treatment (average of four replications) classed from 0 to 4. San Joaquin Valley, California.

Treatment	Weighted root index	Percent of nematode control
	A. Row treatments two weeks prior to planting	
1 chisel 3.9 gal./acre	48.9	25.4
1 chisel 6.9 gal./acre	35.0	46.6
1 chisel 9.5 gal./acre	24.3	75.7
2 chisels 12.0 gal./acre	17.0	83.0
Untreated	65.6	--
	B. Row treatments at planting time	
1 chisel 3.4 gal./acre	52.9	21.7
1 chisel 6.6 gal./acre	34.1	49.6
2 chisels 6.5 gal./acre	38.5	43.0
2 chisels 12.7 gal./acre	18.9	72.0
Untreated	67.6	--
	C. Flat treatment four weeks prior to planting	
20 gal./acre	1.6	96.6
Untreated	67.7	--

any correlation to treatments, either by dosage, time, or method of application.

Yield -- The experimental plots were harvested by hand and the first picking was made on October 29 to 31. A second picking was made on January 24, 1953. These data are listed in Table 1. The yields obtained in the untreated plots were higher than was expected from such heavily infested soil. In addition the yields from the treated plots were in general above average. In both cases the high yields may be due in part to the abundant fertilizer that was applied. The data show the increased value of the crop from each treatment, which was sufficient in every case to return to the grower an amount far greater than the cost of fumigation. Although the flat treatment involves a considerably higher cost it had been known from previous experience to be an excellent method of controlling root-knot nematode and in these tests it gave by far the greatest increase in yield of any of the treatments.

Root Index -- Following the final picking of cotton from the plots plant roots were examined

to determine the degree of root-knot nematode infection present at the end of the growing season. The roots of 100 cotton plants were examined from each replicate. These roots were placed in five classes from 0 to 4 according to the degree of infection found. Plants classed as 0 were free of root-knot nematode galls, those in class 1 had 1 to 25 percent, class 2 26 to 50 percent, class 3 51 to 75 percent, and class 4 76 to 100 percent of the roots with galls. To arrive at the index each class was weighted by the factor of 0, 1, 3, 5, or 7 for the classes 0-4 respectively, then the total divided by 7. These results are shown in Table 2 and clearly show that the flat treatment was much more effective than any of the row treatments in reducing the root-knot nematode population. However, it is also apparent from these root gall examinations that it is not necessary to kill all of the root-knot nematodes in the soil in order to obtain satisfactory growth of plants in fumigated soil.

DISCUSSION

The results obtained from row treatments are very encouraging and this method of application shows great promise for substantially reducing the cost of controlling root-knot nematode in cotton land. However, one difficulty encountered in the row treatments resulted from the undecomposed roots and plant parts, which caught on the chisels and disturbed the beds excessively, by loosening the soil in the area where the seeds are planted. This condition could possibly dry out the soil too rapidly, with an adverse effect on germination. In some cases the loose soil also resulted in seeds being planted too deep. This difficulty can probably be avoided by fumigating at the same time the beds are formed, which would offer the additional safety factor of treatment well before planting time since further investigations are needed concerning the possibility of phytotoxicity in different soil types and under varying weather condition before treatment at the time of planting can be recommended for general use.

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OBSERVATIONS ON THE CLOVER ROOT NEMATODE IN CALIFORNIA

D. J. Raski and W. H. Hart

In August, 1951, an area of poor growth was observed in white clover in the lawn of a private residence in Camarillo, California. In a circular spot approximately ten feet in diameter the clover showed yellowing and poor growth. A sample of soil and roots from the clover was collected by Inspector W. M. Jones of the Ventura County Agricultural Commissioner's office and forwarded to the Bureau of Plant Pathology of the California Department of Agriculture, Sacramento. This sample was found to be heavily infested with a cyst-forming species of Heterodera. Subsequent examination of surrounding properties showed infestations in two other lawns in the near vicinity.

Soil from the infested lawn was used in testing the host range of this species. In the first tests, started February 6, 1952, the plants tested were seeded directly into the infested soil in pots in the greenhouse and allowed to grow approximately 70 days. After that time the roots were washed clean and examined for females and cysts. The soil from each pot was washed and examined for larvae and males. Results of the first tests are listed in Table 1.

A careful search of all this material and of all subsequent tests showed no males present or detectable from any of the host plants.

On May 18, 1952, the test was repeated for sugar-beets in sterilized greenhouse soil infested with the washings and roots from the Golden Wax bush bean, white clover, and carnation used in the preceding test. In addition, ten females and one cyst from Golden Wax bush bean were used in another pot of sterilized soil. The sugar-beets were allowed to grow for approximately 70 days and then examined. No females or cysts were found on the roots and no males in the soil washings.

On June 16, 1952, host tests were made with the plants and results indicated in Table 2. The results with table beets may possibly be considered inconclusive because of the shorter period of growth of the host plants.

On August 20, 1952, another series of plants was planted in infested soil and grown for 126 days. The results are tabulated in Table 3.

In 1951 Franklin (3) summarized the observations made by Goffart (5) and Franklin (2) on the host range of this nematode, as follows:

Leguminosae Infected by Clover Heterodera

	Goffart	Franklin
Trifolium repens	++	++
T. pratense	++	++
T. incarnatum	+	–
Phaseolus vulgaris	++	–
Pisum sativum	–	+
Vicia sativa		++
V. villosa	++	
V. narbonensis	+	
Lupinus sp.	–	
Medicago sativa		–

Other records also listed by Franklin at that time include Stellaria media, Galeopsis speciosa, Rumex spp., Isatis tinctoria, Brassica alba (very lightly) and Beta vulgaris (lightly).

The results of our work agree in general with the above observations, Sesbania and carnation being the only new host records. The main differences between these records are that Franklin was unable to infect Phaseolus vulgaris, Goffart was unable to infect Pisum sativum, and in our work it was not possible to obtain development of this nematode on sugar-beets.

Hastings and Bosher (6) report the occurrence of a species of Heterodera in the coastal regions of British Columbia and in western Washington which appears to be H. trifolii. Two

Table 1

Test plant	Nematodes observed in 70 days
White clover (Trifolium repens)	Very heavy population of females
Carnation (Dianthus caryophyllus)	Very heavy population of females
Golden Wax bush bean (Phaseolus vulgaris)	Very heavy population of females; three cysts
Sesbania macrocarpa	One female; five cysts
Garden pea (Pisum sativum)	Two females
Sugar-beet (Beta vulgaris)	None

Table 2

Test plant	Source of nematodes	Number of days host plant grown	Nematodes observed
Sesbania macrocarpa	Five cysts from roots of Sesbania	107	Heavy population of females
Table beets (Beta vulgaris)	Infested soil	51	None
Curly dock (Rumex crispus)	Infested soil	67	Very heavy population of females

Table 3

Test plant	Nematodes observed after 126 days
Ladino clover (Trifolium repens var. latum)	Heavy population of females; some cysts
Red clover (T. pratense)	Six females
Strawberry clover (T. fragiferum)	One female
Alsike clover (T. hybridum)	None
Subterranean clover (T. subterraneum)	None
Alfalfa (Medicago sativa)	None
Burr clover (M. hispida)	None
YB Sweet clover (Melilotus officinalis)	None
Birdsfoot trefoil (Lotus sp.)	None

separate collections made in British Columbia were originally identified as H. trifolii from vetch and other legumes near Victoria and H. gottingiana from peas at Ladner. Their record of the population from Victoria on peas was not conclusive, otherwise the host ranges of both collections were very similar. They also reported successful transfers of the nematodes from both collections to alfalfa (Medicago sativa) and sweet pea (Lathyrus odoratus).

In addition to these host range characteristics it was noted that the population observed in California showed a distinctive yellow phase in the color of the female as it turned from white to brown. This color phase is described by Franklin (3) and Jones (10). According to Ichinohe (9) this yellow color phase also occurs in Heterodera glycines, which is found in Japan on soybean (Glycine max) and on Phaseolus vulgaris. No such color phase has ever been reported for H. schachtii.

Measurements of larvae showed a total length of 0.480-0.542 mm. (average 0.517 mm.) with a spear length of 26-29 μ. These measurements agree with figures reported by Franklin (3). No males were available for comparison with published descriptions. There seems to be no explanation for the failure of the males to develop in these tests. The larvae of the clover root nematode are distinctly longer than those of H. schachtii, which average 0.469 mm. in length.

The clover nematode was first described as a variety of H. schachtii and given the varietal name of trifolii in 1932 by Goffart (4). In 1944 (5) he designated it as H. schachtii trifolii on the basis of further studies. Franklin (3) also considered it a variety of H. schachtii. Oostenbrink (12) referred to this nematode as H. trifolii in 1949 and Steiner, et al. (13) also considered it as a separate species in discussing the various species of Heterodera present in the United States. In view of the greater length of the larvae, the yellow color phase of the female, and the differences in host range, the authors are of the opinion that this nematode represents a species distinct from H. schachtii and that it should be referred to as H. trifolii Goffart, 1932. It is expected that further studies will disclose other morphological as well as biological differences.

A collection similar to this reported by McBeth (11) in Salt Lake City is the only record up to the present time of the presence or distribution of this nematode in this country. It is also known to occur in Canada (6), Europe (4, 5, 7, 8, 12), and in England (1, 2).

There is no conclusive evidence as to the origin of the infestations found in California. It was determined that the area at Camarillo had been planted to barley for many years and that the soil was too poor to grow good crops. The area was sub-divided for home sites in 1948 and subsequent growth was volunteer barley, wild oats, and Russian thistle. As homes were built many owners scraped off top soil and imported other soil, much of which came from Camarillo Heights, a high ridge nearby with a considerable growth of native vegetation, such as lupine, vetch, etc. It has not been possible as yet to investigate that area for possible native infestations of the nematode. Apparently it was not introduced in the clover seed since a portion of the original seed used in planting one of the infested lawns was available for examination. No nematodes were found in that portion of the seed. The original lot of seed at the nursery was traced to plantings in other areas, which were checked and no infestations were found.

So far this species is known only from this one locality in California and has not been collected in any commercial plantings of clover. However, it appears to be very destructive on clover and on the basis of its host range may represent a potentially serious pest in the production of clover as well as other crops in this State.

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POTATO ROT CAUSED BY THE IRIS BULB NEMATODE IN BRITISH COLUMBIA[1]

J. E. Bosher[2]

In September, 1952, potato tubers that had been grown in a small plantation on Vancouver Island, were found to have an unusual greyish rot, similar to that described for the disease caused by the potato rot nematode (Ditylenchus destructor Thorne). Approximately 0.5 percent of the stock of potato tubers were infected. Three varieties were involved, namely, Green Mountain, Great Scot, and White Rose. Infected tubers of each variety were found, but it was not possible to determine the amount of infection in each variety, because the whole stock was mixed after being dug.

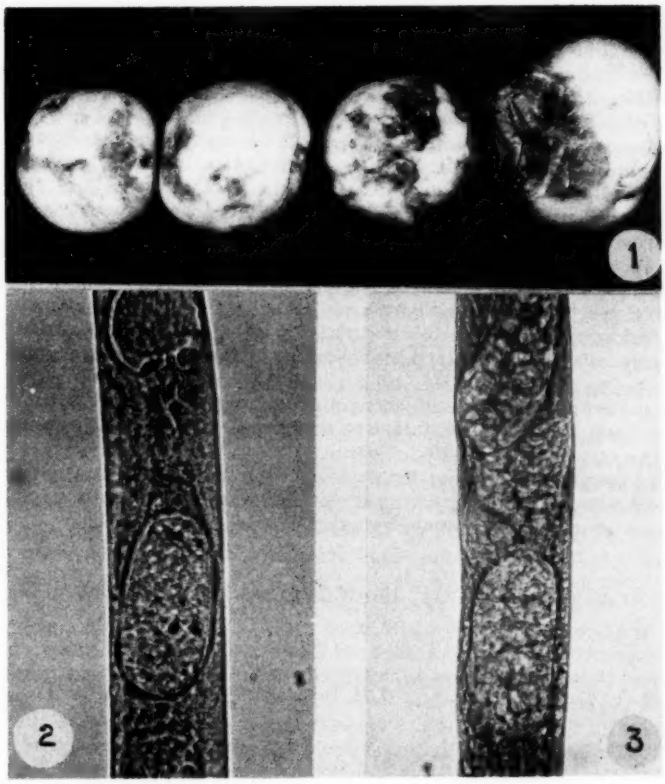

FIGURE 1. Potatoes showing symptoms of rot induced by the iris bulb nematode.

FIGURE 2. Body section containing egg of Ditylenchus from potato.

FIGURE 3. Similar section of Ditylenchus dipsaci from narcissus.

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An examination of the greyish lesions revealed that the infected tissues contained large populations of nematodes of the genus Ditylenchus in all stages of development. This observation was of special interest, because the potatoes had been grown on land previously planted with bulbous irises of the variety Wedgewood, that were known to have been infected with the bulb nematode, a species which has been identified until recently as Ditylenchus dipsaci (Kuhn) Filipjev.

Examination of the nematodes from the potato tubers showed that they possessed six incisures in the lateral fields, a rounded tail tip, and an elongate basal lobe of the oesophagus, characters that have been used for distinguishing D. destructor from D. dipsaci. However, the ratio of the length of the eggs to the body width of the nematodes (Fig. 2) was from 1.25 to 2.16, averaging 1.63 in 20 specimens measured, whereas the eggs of D. destructor are described as being about as long as the body diameter. The eggs of D. dipsaci are recorded as being two to three times the body diameter (Fig. 3).

Infected potato tissue from this source was used to inoculate steam-sterilized soil in three pots planted with a total of 15 bulbs of the iris variety Wedgewood from a source known to be free from nematodes, and two pots containing 10 bulbs of the giant snowdrop (Galanthus elwesii). Examination of the bulbs after three months growth in a cool greenhouse showed that the iris bulbs all contained heavy populations of Ditylenchus and showed greyish streak lesions typical of that produced by the iris bulb nematode. The snowdrop bulbs were also infected, but in some cases the infection extended from the top of the bulbs into the fleshy scales, in addition to the more normal progress of infection from the base of the bulbs. No nematode infections were found in the uninoculated pots of iris and snowdrops grown from bulbs obtained from the same source as the ones planted in the inoculated pots.

Specimens of the infected potatoes were submitted to Dr. A. D. Baker, Officer-in-Charge, Nematode Investigations, Division of Entomology, Ottawa, who kindly confirmed that the infection was typical of that caused by the potato rot nematode. He stated that the nematodes involved could be referred to as Ditylenchus destructor, pending further study of the populations in both potato and iris and possible future clarification of the range of characters of D. destructor.

This is the first record of the potato rot nematode from the field in British Columbia and there appears to be little doubt that the infection occurred as a result of planting potatoes on land infested with the iris bulb nematode. Fortunately, in this case the potatoes were used entirely for culinary purposes and since the bulb-growing districts of British Columbia are remote from the commercial potato-growing areas, there should be little possibility of this nematode becoming a menace to the potato industry of this province.

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CHANGES IN BASIC CONCEPTS IN PLANT NEMATOLOGY

G. Steiner

A discussion of recent and proposed changes in current basic concepts in plant nematology should be of interest and help to the plant pathologist. First to be mentioned are changes in the concept of the taxon. Plant nematodes and related soil forms are still only partly described and the descriptions of even the best known forms are very incomplete. Of late years some progress has been made. It has been established that certain single species as they were previously conceived are in fact groups of species, in instances even groups of genera. To understand this situation, it must be emphasized that these changes in concept of the taxa in plant nematodes were not searched for through theoretical considerations and notions of taxonomists, but rather are the results of practical needs. Observations and experimental work had demonstrated that various so-called species of plant nematodes did not behave as uniform species. Populations of such species from different locations frequently showed unexpected differences in behavior. Plants attacked in one region were not attacked in another by nematodes considered to belong to one and the same species. Some populations of supposedly the same species withstood climatic rigors that for others were lethal. These phenomena were and still are explained by the assumption of the presence of different races and strains. Unfortunately these assumptions and conceptions are of little help in control and regulatory work. If the identity of an organism has to be determined by experimental tests of at least one month's duration, control and regulatory work is not only hampered but often made impossible. The problem of how to distinguish these taxa by morphological characters has been with us for a long time. Let us exemplify this. There had been established a quarantine against Ditylenchus dipsaci (Kuhn) in narcissus bulbs, while forms considered to be the same species but which infected other hosts, were not quarantined. It is true that the narcissus form had been shown to behave in some instances at variance with forms from other hosts, and the presence of different races and strains was thus assumed, but good and practical characters to differentiate these various taxa were lacking. Thus practical needs made necessary a much more detailed study of the structures of our plant nematodes.

Nematodes are organisms which have all the organ systems of higher animals except a respiratory-circulatory system; all these organs however are packed into an extremely small space, making their study difficult. It was therefore thought that a detailed restudy with optical means of highest power and quality and a careful comparison of the most minute structures and features might furnish the basis for improvements in the concept of their taxonomy. As a result the concept of the taxon in plant nematodes is becoming much sharper and its foundation on morphological characters has important practical significance and application. This may be demonstrated by a few examples. The concept that the root-knot nematode represents a single species of world-wide distribution has already been discarded. But instead of the five or six forms that have now been established there will be dozens of species distinguishable on morphological characters. An exact identification of the one or several species in a field will make it possible to recommend an efficient control by rotation, provided the host-range of each species has also been established. To fully appreciate this improved concept of the taxon one must not forget that crop rotation is still the most practical control method for numerous plant nematode pests. But this is not the only practical result of this change. Attempts to breed resistance against these pests of plants will be more promising if the various species can be properly identified. Earlier disappointments resulting from the fact that a resistant crop type developed and proven in one region was found non-resistant in another will be avoided. Regulatory work too will profit from this progress, and be made much more efficient through such improvement in the concept of the taxon. The narcissus bulb nematode has already been mentioned as an example of regulatory confusion because it was not identifiable morphologically or physiologically. It now has been established that Ditylenchus dipsaci as formerly conceived is not a single species but also a group of species and that one single host may harbor not only one but two or more different species. These were formerly confused and the cause of contradictory results of experimental tests. Let us express the hope that the tobacco cyst nematode, at present considered a strain of the golden nematode of potatoes, may eventually also be distinguished on morphological characters and be proven a separate species. Thus it might be made more amenable to control and regulatory actions. This change in concept of the taxa of plant nematodes is of course not restricted to the few forms mentioned but is equally ascertained for many other forms, such as the meadow nematodes, the seed gall forming types, the aphelenchi, and others, including numerous soil forms. Nematologists will have to learn to

know their subjects better to evaluate fully and interpret properly the results of experimental tests.

The second change in concept to be discussed concerns the broad aspect of parasitism of nematodes in and on plants. Some years back nematodes, in order to be considered parasites and pathogens of plants, had to be found inside the plant. Not infrequently the question was asked whether a nematode, being described as a plant disease agent, actually was found inside the host tissues. A negative answer produced the result that one's statement of its pathogenic nature was not only doubted but directly rejected. This attitude ignored the fact that nematodes are well fitted for an ectoparasitic mode of life, particularly on underground plant parts, but also above ground, especially in tufts of plants, in buds, and between sheaths of leaves. Today the concept of parasitism of nematodes in plants equally embraces endo- and ectoparasitism and includes also that type of ectoparasitism which in zoological terminology is called planositism. Planosites are vagrant parasites. In the case of plant nematodes the term applies to those forms that feed on roots from the outside and migrate from place to place, from root to root. This kind of parasitism, once completely ignored in plant nematodes, is of wide occurrence and of epidemiological significance.

The third change of concept to be mentioned is from that of a presumed prevalence of single infections and pure populations, to that of actual prevalence of multiple infections and mixed populations. In field observations and in experimental plot and field studies the assumption is usually made that there is just a single taxon (species, race, strain) of plant nematode involved. Yet under field and plot conditions such is unquestionably the exception. A plant is usually attacked by a multiple number of taxa (species, races, strains) of nematodes, which may be endo- or ectoparasites, but are particularly planosites. One or more species, races, or strains may be prevalent, but it is not necessarily the most numerous one that produces most damage. Likewise, it is usually assumed that an existent field population consists of a single pathogenic nematode form. This again is the exception; most frequently field and plot populations of plant nematodes are made up of a variety of forms. The disregard of this situation has been a cause of discrepancy in experimental work, particularly in soil fumigation. The so-called stimulation of crops produced by nematocidal soil fumigants may frequently be the result of an ignored control of multiple infections and mixed populations instead of that of the single infection and pure population assumed by the experimenter. Nematocidal soil fumigants will also control the overlooked crop antagonistic nematode types and thus produce a better result than anticipated.

A fourth change of conception relates to the so-called saprobic nematodes so frequently found associated with diseased plant material. These nemic saprobionts should not be considered as wholly nonpathogenic. Aside from the possibility that some of them may be crop antagonistic, others neutral, and still others beneficial, some are unquestionably facultative parasites fully able to invade healthy tissue (e.g. species of Aphelenchus), while a large number of them are carriers and distributors of bacteria and to a lesser degree of fungus spores (e.g. Panagrolaimus, Rhabditis).

There is still a fifth change of concept to be mentioned here, -- one of particular interest to the pathologist and regulatory worker. It is the concept that plant nematodes are spread and distributed mainly with their host plants. Such spread may prevail with certain nematodes, especially those living as endo-parasites. However, the planosites, as previously stated, and many other ecto-parasites and soilborne endoparasites are distributed not only with their host plants but with infested soil and a variety of materials that come in contact with such soil. Root crops and plants having dense roots or other underground parts which offer hiding and retention places for nematodes are important carriers. Therefore any such material from an infested region may be an instrument of distribution of plant nematodes. Thus the concept of the mode of distribution of these organisms is modified so as to include as a carrier any kind of plant or packing material liable to come in contact with soil. A few examples may serve to emphasize this point. Cooperative work with the Division of Foreign Plant Quarantines of the Bureau of Entomology and Plant Quarantine has shown that cysts of the various heteroderas such as the sugar-beet nematode, the golden nematode of potatoes, the pea cyst nematode, and the oat cyst nematode are actually being brought to this country on many types of carriers other than their host plants, e.g. on lily-of-the-valley pips, on soil around any plant from infested regions, as on tulip bulbs, shamrock, heather, and so on. Used bags, used packing materials, used sticks, especially hollow bamboo stakes and similar conveyances for small soil quantities, are frequently vehicles for plant and soil nematodes. It is true that the majority of these organisms after their trip are dead or damaged beyond recovery, still, some are living and under favorable conditions able to establish new foci of infestation. If the overall situation

of plant nematode pests in our country is analyzed with this modified concept of their spread in mind it becomes evident that the increases in crop losses attributed to nematodes are not only a product of our better awareness of these pests but a result of an actual increased distribution. Considering the fact that these pests, if once established in a soil, are extremely difficult to eradicate, the seriousness of these growing pest problems is not just a matter of imagination.

In conclusion may we refer to still a further change in concept. It concerns the fact that soilborne plant diseases are at least in some instances of complex character and that nematodes quite frequently are members of such complexes, acting as either initiators, cooperators, synergists and aggravators, or otherwise. Here must be considered not only the plant parasitic types of nematodes but the whole array of soil forms. Nematodes in relation to plants should not be considered exclusively as single and detached entities but as members of a complex biotic community.

DIVISION OF NEMATOLOGY

EVALUATION AND USE OF DISEASE RESISTANCE BY VEGETABLE BREEDERS[1]

C. F. Andrus[2]

Introduction

The extent of vegetable breeding on this continent has increased continuously during the last 40 years. This is due in part to the natural tendency of all human projects to become bigger and bigger under the quaint philosophy that when a thing stops growing it will die. I think the increase in vegetable breeding activity is due in part also to the newly realized possibilities in disease and insect resistance. The old projects have continued with objectives often unchanged, but new projects have been organized with the definite objective of seeking resistance to one or more of the many diseases of vegetable crops.

What is the general attitude of vegetable breeders toward resistance to diseases and insects? There are mostly three kinds of breeders: Those who entirely neglect the possibilities in disease resistance, those who overestimate the value of resistance alone in varieties, and a smaller number, perhaps, that have learned to keep disease resistance in a balanced perspective with other objectives.

Webster defines "perspective" as the "interrelation in which parts of subject are mentally viewed"; also as the "capacity to view things in their true relations or relative importance: as, some folks cannot see the wood for the trees, while others have perspective." We anticipate that more and more vegetable breeders will come out into the open and get a longer and broader view of the needs and possibilities in crop breeding. We shall try to point out some of the real gains that can be expected from disease and insect resistance and also some of the limitations to which the breeder must become reconciled.

If we could start all over, how could we best organize our resources for a systematic program of breeding for disease and insect resistance? How much can world food production expect to gain from the benefits of resistance? How shall we avoid the real dangers of both under-emphasis and over-emphasis of disease resistance? How much have we learned in 40 years? We shall not answer all these questions. Indeed, the purpose of this paper is to raise questions rather than answer them. Ideas are sometimes more important than facts. We shall, however, point out some of the things that have been learned in the last 40 years.

Resistance Value Over-Estimated

The development of the wilt-resistant Conqueror watermelon by W. A. Orton in 1911 was the first recorded attempt in this country to produce a disease resistant vegetable variety by hybridization. From a practical standpoint this accomplishment proved to be a failure because the Conqueror variety was unsuitable for commercial use. Yet, at the time of its development, it was believed that the Conqueror variety would transform the industry. Ultimately it served a useful purpose because it was the source of resistance for new varieties produced later in California and Iowa.

Probably the incident of the Conqueror watermelon is also the first case of over-emphasis of disease resistance. Here at the beginning of scientific vegetable breeding it was demonstrated that disease resistance will accomplish nothing unless the resistant variety has also the other characteristics required for successful cultivation. Dr. Orton was a plant pathologist and a great credit to the profession of plant pathology. He performed a service for all of us by this early demonstration that professional enthusiasm must be tempered with practicality.

In later years some of our most practical breeding work has been accomplished by pathologists; but we have ample proof that a vegetable breeder does not have to be labeled a pathologist in order to work successfully with disease resistance.

How much pathology should a vegetable breeder know in order to work on disease resistance? It might be asked also: How much horticulture should a pathologist know before he tries to develop new resistant varieties? These are important questions. Today in vegetable breeding we are at a stage where professional labels can be forgotten and we should ask how much background does the breeder have in plant science and how much common sense can he be depended

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upon to exercise.

Resistance to disease or insects has become an important consideration in the breeding of nearly every vegetable crop. Among vegetable breeders are pathologists who have had little or no formal training in horticulture, and there are horticulturists who have had very little formal training in pathology. We could point to instances where each of these has quickly organized the knowledge and skill needed for his particular problem. It seems that the name of the training a man has is relatively unimportant provided that he is still able to acquire knowledge and to exercise judgment. The real weakness is not inability to handle problems, but the failure to recognize the problems and opportunities that exist.

We have learned that disease resistance alone is worthless, but that combined with other suitable characteristics it can expand our food resources. There is seldom any excuse for introducing a disease-resistant variety unless adequate trials have shown it to be commercially acceptable. Every new variety should have extensive commercial trials before it is finally released, but these are particularly needed for disease-resistant varieties, because of the temptation to over-estimate the value of resistance itself. Experience with pre-release commercial trials in the South has shown their great value and we believe every vegetable breeder should make use of widespread testing prior to releasing new kinds.

An exception can be made in the case of a stock that may have exceptional breeding value; in such a case its commercial possibilities may be disregarded. It is characteristic of breeders that they will use a stock more readily after it has been released as a named variety than they will while it exists only as a number in some other breeder's collection. There is sometimes good reason to release a variety that has a genuinely new character even though the variety is not expected to have much commercial use. If this is done, its limitations should be clearly stated.

We have learned that with some crops the continuous production of new varieties that lack disease resistance is a waste of resources, for in that we are ignoring factors of great value that are available and waiting to be used. Such varieties have little possibility of extensive use in the future and will add to the confusion in our seed catalogues. There is no excuse at present for ignoring disease resistance that is as readily available as, for example, resistance to mildews in cantaloupes and cucumbers; mosaic, powdery mildew and rust resistance in beans; fusarium wilt and collar rot resistance in tomatoes; yellows resistance in cabbage; and anthracnose and wilt resistance in watermelons.

Each breeder should consider the whole disease complex of his crop and know what possibilities for resistance may be available, but from a practical standpoint he will often find it necessary to attack these problems one at a time and consolidate his gains at each step. It is not always advisable to withhold a good variety merely because it is expected that something better will be ready a few years hence.

Vegetable breeders are justified in attaching high value to disease resistance; at the same time they must be cautioned that disease resistance will not always give all the benefits that are anticipated. Let us consider some examples.

A watermelon breeding program was started in the Southeast in 1936 at a time when growers were crying for wilt resistant varieties. We thought that wilt resistant varieties would soon transform the industry, not realizing at that time that growers will not abandon an old variety in favor of a new one that is just as good. They will change only to something that looks distinctly better. Since 1936 at least eight wilt resistant varieties have been developed in that area, but none became important. Commercially, some of them were good varieties, fully as good as the favorite susceptible varieties. We thought their wilt resistance would give them that extra advantage that would make them welcome to growers. But it failed to do so.

Wilt resistance failed to give the benefits that we and the growers both expected. Now we begin to understand why. We had made a mistake. Wilt resistance was not what they most needed in that area; it was anthracnose resistance, and now we believe anthracnose resistance will transform the watermelon industry. The first anthracnose resistant variety offered to them was accepted eagerly, not because it was a better variety from a horticultural standpoint, but because its resistance gave benefits even beyond what we anticipated.

So it is easy to be wrong in the diagnosis of the farmers' needs. We are not going to abandon wilt resistance; it will confer some benefits, and in the long run slight benefits can have great economic value. Besides, wilt resistance is easily available and it would be inexcusable not to use it.

On page 123 of the 1937 Yearbook of the U. S. Department of Agriculture the statement is made: "Practically speaking, no research agency today would introduce a new tomato unless it was resistant to at least one very troublesome disease." That statement was overly optimistic,

for in the 15 years that have passed, less than half the many new tomatoes introduced have had resistance to even one troublesome disease, and only a few of the disease resistant tomatoes have found a very important place in commercial production. This is not to cast doubt on the potential value of disease resistance in tomatoes, but is to point out again that a resistant variety needs to offer also distinct horticultural advantages over the old susceptible varieties.

On page 185 of the same Yearbook (1937) it is stated that the variety Marglobe "was introduced just in time to save the Florida tomato shipping industry from virtual extinction through the ravages of nailhead and wilt." Today we seldom hear of nailhead spot (Alternaria sp.) in Florida but wilt is just as prevalent as ever. Farmers are growing susceptible varieties in greater volume than ever before.

The farmers, as well as the breeders, believed that Florida growers needed resistance to nailhead and wilt; and they still need it, but they need certain horticultural characteristics even more. In developing a disease-resistant variety there can be no compromise with commercial adaptability. The advantage in disease resistance in Marglobe was not enough to offset its slight defects in the horticultural characteristics needed in that area.

Today we have a degree of resistance to Fusarium wilt in several varieties much higher than that in Marglobe, but they are all having a similar experience. The failure of Pan America and other near-immune varieties to win wide acceptance is no reflection on the ultimate value of disease resistance; it means that at some point the breeders compromised with commercial adaptability.

One of these days we will produce a wilt-resistant tomato that really clicks. That is the primary objective of a large number of tomato breeding projects today. In the meantime we have reached a stage in our understanding of tomato diseases where our objectives need to be extended to include resistance to several other ailments. Such resistance is available and we would be foolish to ignore it. Indeed we might discover that resistance to early blight (Alternaria solani), for example, would confer benefits that would be astonishing.

It is possible that the importance of Fusarium wilt has been over-estimated. Wilt tends to be localized, but early blight is almost universal over the Southeast. Wilt will sometimes destroy a tomato crop, but if it escaped wilt through resistance it might be destroyed anyway by early blight. Hence resistance to wilt alone will do only a part of what we might expect. Resistance to wilt and resistance to early blight and other foliage diseases need to go hand in hand.

The same can be said of other vegetable crops. The breeder needs to consider the whole disease picture. Conferring resistance to one disease may only open the way for another, and the breeder's hopes are frustrated. This leads us to consider some other limitations on disease resistance.

The occurrence of antagonism among microorganisms is well substantiated; less known is the fact that this antagonism can be expressed on the plant as well as in the culture plate. Some diseases of the same host don't get along together. I think this is true of leafmold (caused by Cladosporium) and some other foliage diseases of tomato; if one is present the other fails to develop fully. This leads us to err in the evaluation of disease problems. We may say that one disease is less important than another, whereas if the first disease is eliminated by a resistant variety the second disease may move in and prove to be just as destructive as the first, and we are apt to feel frustrated.

Another limitation of disease resistance results from its effect on bearing season. One of the principal effects of disease resistance is to prolong the bearing season, but when we extend the season of production the plants resistant to a particular disease may run into climatic conditions that permit another and perhaps hitherto unimportant disease to come in. And again we are unable to reap the full benefits we expected from resistance.

Another limitation is in the resistance genes themselves. Apparently some genes are incompatible and when you succeed in getting them together in the same germ plasm something goes haywire. It is possible that this happens when you get resistance to Alternaria and resistance to Stemphylium together in the same tomato; we get several kinds of lethals and queer plant types but seldom anything of decent horticultural quality. Resistance to Alternaria and resistance to Fusarium go together splendidly, also those to Stemphylium and Fusarium, but thus far the inclusion of the genes for resistance to Alternaria and to Stemphylium and those for adaptability and good market characters in the same variety has not been satisfactorily accomplished.

Another limitation is in the association of resistance with some particular plant or fruit type. Cladosporium resistance seems to be associated with a particular vine type, one that is suitable for hothouse production but not field cultivation. Difficulties like this delay a breeder's work but are not necessarily insurmountable.

Another limitation is the failure in diagnosing all the causes of a disease. Tomato wilt offers a good example. Very similar wilt symptoms are caused by two fungi and a bacterium. Fusarium wilt was considered a strong limiting factor in tomato production in east Florida and it was supposed that new varieties with resistance to the disease would solve the problem. But resistant lines planted in that area still developed wilt, which on closer examination proved to be bacterial wilt. Now the pathologists have more respect for bacterial wilt. Previously considered unimportant, it is now thought that bacterial wilt may have been present all along and accounted for a considerable part of the losses formerly attributed to Fusarium wilt. Disease resistance again failed to give all the benefits predicted and the whole solution is still far in the future. Tomato breeders in the South now include bacterial wilt resistance in their program.

The pathologist cannot be expected to identify in advance all the possible causes of a disease, particularly where new strains or new physiological forms of the pathogen are apt to appear; but the breeder should be aware in advance of this strong limitation on the results of his work.

One other limitation on the value of disease resistance is illustrated by Fusarium wilt of watermelons. Growers have been led to think that with suitable wilt resistant varieties they can grow good crops of melons on the same land continuously for several years. We now believe this is a mistake. We now believe that crop yields would decline sharply after the second or third year on the same land, and that even with the highest degree of disease resistance possible it would still be necessary to practice crop rotation. This leads to one general observation concerning the limitations in disease resistance, namely, that all the resistance in the world will not substitute for good farming practices.

Resistance Value Under-Estimated

We have described a number of circumstances that may lead a breeder to over-estimate the importance of disease resistance. There are also a number of circumstances that may lead to under-estimation of the benefits to be derived from resistance. One of these is failure to evaluate properly the importance of different diseases.

It can be said that there are regional situations which would justify the neglect of resistance to particular diseases. Breeders sometimes feel that their responsibilities are limited to their particular areas. For example, a cantaloupe breeder in the Southwest might feel justified in ignoring resistance to downy mildew but not to powdery mildew. In the Southeast, on the other hand, a cantaloupe breeder might feel justified in ignoring resistance to powdery mildew but not to downy mildew. But since resistance to both is available, why not make use of it? It is to the advantage of each crop industry to have varieties that are as widely adapted as possible.

If resistance to a disease is readily available there is no excuse for ignoring it even though it seems to have no bearing on immediate local problems. We can see too many instances where local problems have not been fully understood.

In the Southeast we thought powdery mildew of cantaloupe was of no concern. But we find now that if the foliage holds late in the season powdery mildew will develop. Thus, where we have downy mildew resistance we begin to see the need for powdery mildew resistance also. We thought anthracnose of cucumbers was unimportant; but now that we have mildew resistant cucumbers we find that anthracnose develops on the longer bearing vines.

Another instance of under-estimation is the failure to estimate properly the value of a low level of resistance. Today pathologists recognize that resistance is seldom absolute and is nearly always relative. We call some varieties resistant but mean actually that they are less susceptible than others. The Marglobe tomato originally was considered to be resistant to Fusarium wilt. Today we consider Marglobe to be susceptible but still recognize that many other varieties are far more susceptible. The difference in degree of susceptibility of Marglobe and Indiana Baltimore in the Midwest sometimes proved to be the difference between a good crop and a very poor one.

Where a high level of resistance is lacking the breeder may still be able to exploit low levels of resistance or differences in degree of susceptibility, and sometimes the results will be beyond his expectation. A distinctly higher degree of susceptibility occurs in many vegetable crops and the breeder should make certain at least that his new productions do not fall in this most susceptible class.

A good example of extreme susceptibility is found in the Ontario tomato. In our observations in the South, Ontario is extremely susceptible to several foliage diseases, including

Septoria leafspot, Stemphylium leafspot, and late blight. In strong contrast is the variety Rutgers which in controlled inoculations must be called susceptible to all these diseases, but which nevertheless proves to be less susceptible than many other varieties in the field. I believe the present wide popularity of Rutgers in the South is due in large part to this factor, not of high resistance but of definitely less susceptibility than other varieties to several diseases.

Where the level of infection is very high, differences in degree of susceptibility may be obliterated and we are apt to conclude that they do not exist or if they do exist that they have no value. This has happened in the case of late blight of tomatoes. Tomato varieties do differ in their degree of susceptibility to late blight, but observers have seen these differences obliterated at a high level of infection and have decided that they are unimportant. They have under-estimated the value of low level resistance. A delay of a few hours in the build-up of an epidemic of late blight might mean the difference between success and failure of the crop; and, especially if the less susceptible variety is grown in isolation from more susceptible varieties, the infection might not reach a high level.

The same principle could reasonably be expected to apply in the case of many other vegetable diseases, such as the mildews of cucumbers, beans, and cantaloupes, septoria leafspot of tomatoes, and some insect injuries such as earworm damage to sweet corn. If breeders can do no more than eliminate extreme susceptibility the results might go far beyond their expectations.

Evaluating Source Materials

The same principle concerning better evaluation of low level resistance should be applied to our reappraisal of source materials. This country, mostly through the Division of Plant Exploration and Introduction, has accumulated a large reservoir of vegetable stocks among which vegetable breeders hope to find something of value in the improvement of their several crops. Everybody seems to be just a little perplexed as to how to get the most out of this material, how best to appraise it, and how to keep each line going until it can be properly evaluated.

Several fragmentary lists, partly surveying the stocks of particular vegetables in respect to a relatively few characteristics, have been issued in mimeograph form. We are just nibbling at the edge of the cheese. The first impression a horticulturist gets when he grows a collection of these foreign accessions is that of utter worthlessness. But we should not expect to find good characters ready assembled; most of this material is perhaps worthless from a breeder's standpoint, but we cannot know until each character has been observed independently. A single valuable gene can be hidden among worthless features.

Any procedure that will help us study source materials more effectively will be welcome. In 1950 the Regional Coordinator, Southern Project PEI, obtained the collaboration of several workers, mostly pathologists, in screening tests of PEI accessions for resistance to several diseases of tomatoes and watermelons. This is a step in the right direction and should be extended to other crops. More recently the Midwest PEI project leaders sponsored similar cooperative tests on tomatoes. In order to avoid over-duplication, leaders in these two projects are trying to get together and organize the disease tests on a national basis. For this and other purposes a uniform and mutually satisfactory system of records needs to be devised. A form developed and used in the southern region proved to be reasonably satisfactory but we need something better, something that can be used for all crops and all diseases. The present procedure requires a different form for each crop.

In Table 1 is proposed a uniform rating sheet for untested varieties, wild types, and foreign accessions which we believe is applicable to all vegetable crops and diseases. A great portion of the accumulated stocks of foreign vegetables and wild types could be quickly eliminated if all horticulturists and pathologists interested in them would use the same rating sheets and turn their records in to the PEI regional projects. The proposed sheet will be used in some of the 1952 screening tests.

The main thing we need to know about the foreign stocks is whether they offer any unusual qualities or any disease resistance not otherwise available. If they have no new qualities we should throw them out and waste no time in routine description. We recommend the adoption of this uniform rating sheet by all vegetable breeders who are growing any foreign accessions.

Probably the greatest need is for a system of rating disease or insect resistance in such simple terms that it can be used by pathologists, entomologists, and horticulturists alike. Specialists are by necessity meticulous in defining various reactions to different diseases.

Table 1. Uniform Rating Sheet for Foreign Accessions

Accession	No. of plants	Unusual Qualities				Disease reaction[a]					Value
		Plant	Leaf	Flower	Fruit	1	2	3	4	5	

[a]1. Most resistant. 2. Less resistant. 3. Mixed doubtful. 4. Less susceptible. 5. Most susceptible. (Indicate which disease.)

Infection level: High _____; low _____; optimum _____.

They may count the number of lesions per leaf or number of larvae in a particular stage of development and end up with an elaborate rating system that requires statistical treatment for interpretation. Such procedures are often necessary in preliminary or basic studies of new diseases or insects, but when resistance to a disease reaches the stage where it is available for use in breeding, such refinements usually are unnecessary and even a hindrance to the widest application of knowledge.

The five classes of disease reaction proposed in Table 1 have been used successfully for several diseases and probably can be used successfully for classifying varietal reactions to practically all vegetable diseases and insect injuries. They constitute what we believe is a minimum rating system. The system is balanced, and a practical measurement of disease reaction can be reached by reference to either end of the scale. We believe this system is more adaptable to different levels of infection than are most other disease classifications.

We would like to see the group assembled here adopt this rating system officially, not because it is the very best but because we know it works. In the meantime a committee could devise a better system that would be even more widely applicable. To get maximum results from cooperative research all procedures and concepts must be reduced to their simplest terms. Otherwise you will find that many people are unable or unwilling to enter into the cooperation and also that the mechanics of assembling and interpreting the records are unreasonably difficult.

Methods of Testing for Resistance

Whatever method is used for classifying disease reaction, it should be remembered that an accurate assay of resistance depends strongly on the level of infection at which the readings are obtained. It will be found that the five classes of reaction in Table 1 are adaptable to different levels of infection, but at a high level different grades of susceptibility tend to merge and disappear so that valuable differences may be overlooked, and at a low level of infection too many plants fall erroneously into a resistant class.

There is an optimum level of infection for every disease at which the various degrees of resistance are most clearly distinguishable, and only long experience will enable a breeder to know when an approximately optimum level has been attained. Any deviations from it must be interpreted cautiously.

There are a number of devices that can be used to control the level of infection in greenhouse inoculations. Some of the most widely useful of these are adjustment of temperature, humidity, age of plant, and strength of inoculum and uniformity of application. In the field, however, the breeder is almost wholly at the mercy of circumstances and is extremely fortunate if he can obtain records at a uniform and optimum level of infection. He will be fortunate also if his records are not confused by the presence of a multiplicity of diseases and confounded by irregularities in plant development. It is extremely important, therefore, that disease tests be conducted under conditions of controlled inoculations wherever possible.

Ingenious methods of inoculation have been developed for most of the important classes of disease, and no matter how long we study methods we will find that further improvements are possible. Therefore it is advisable that the breeder, once he has found a successful method, go ahead and use it and let the pathologists experiment with additional refinements. There is no absolutely best method; the best practical method is any one that you know will give good results.

Some breeders have found that they can save time, space, and materials by inoculating the same plants with more than one pathogen. These are sometimes applied simultaneously and sometimes in succession. In Hawaii, W. A. Frazier was able to inoculate the same tomato plants with Fusarium wilt, spotted wilt, Stemphylium leafspot, and root knot organisms in close succession. In this case perhaps the procedure was justified, but in view of the evidence for antagonism among microorganisms it is generally inadvisable to mix pathogens on the same plant. For the same reason it is inadvisable to rely on field observations if controlled inoculations can possible be made, for it is rare indeed that only one pathogen is present in a particular field.

Disease reactions should be determined on a family basis, inoculating different plants from the same population with the different organisms. This is a slow process. Where segregation occurs it may require several generations to confirm the resistance to several different diseases; yet in the long run errors may be avoided and time saved.

Plant viruses in particular need to be carefully isolated and handled individually, for the immunizing effect of some viruses on other related viruses is well substantiated. This immunizing effect of course may be something different from the antagonistic effects that are believed to occur among different species of fungi and bacteria.

Use of Breeding Stocks

Breeding for resistance to one disease can be very complicated. Breeding for resistance to two diseases sometimes will more than double the complications. We can imagine the difficulties faced by tomato or potato breeders who are trying to develop multiple resistance to eight or more diseases. To most vegetable breeders it might be good advice to suggest that they concentrate on one disease at a time. Fortunately, resistance to two or more diseases sometimes is available already in combination and also may be linked in inheritance; wherever this is true full use should be made of it. If the resistance factors happen to be linked, their retention together is made somewhat easier.

A breeder with one disease in mind is often indifferent to other diseases of the same crop. He may have several primitive types available, all with resistance to the disease he is primarily interested in, and it may be a matter of chance which one he uses as a parent. If his information were a little broader he might observe that one of those stocks possessed resistance to other diseases than the one of primary interest. By not having the whole disease picture in mind he may end up with a variety resistant to one disease but lacking even ordinary tolerance to some other disease.

The wilt resistance of the Pan America tomato came from a primitive stock which was also resistant to Stemphylium leafspot. But at that time we were not interested in Stemphylium leafspot and no tests for resistance were made. The Pan America we have is susceptible to Stemphylium leafspot whereas perhaps it might just as easily have been resistant, for resistance to Fusarium wilt and Stemphylium leafspot are closely associated in inheritance.

Sometimes a breeder may be discouraged by a lack of any high degree of resistance to start with. Where this is true it may be effective to combine low level resistance or less susceptibility from different sources on the theory that there may exist different resistance genes which together would be more potent than when separated. The theory of transgressive segregation is becoming increasingly reputable among geneticists, but at the moment I can not think of any good instance where such segregation has raised the level of resistance to disease. There are, however, a number of instances where it may have occurred. At present it is our best hope for increasing late blight resistance in tomatoes.

Intervarietal crosses often give results that are quite unpredictable; therefore the shotgun methods of plant breeding have some points to recommend them. Indeed, it may be best not to be too wise in selecting parental combinations. There is a field of rich possibilities in the unknown interactions that occur through the reassortment of hereditary factors, and increased disease resistance may be one of the unforeseen results of miscellaneous crosses.

Geographical Sources of Resistance

In examining stocks of foreign vegetables and related species the breeder may think it is sufficient to limit his survey to those stocks that come from the center of origin of the particular crop. It is commonly believed that genes for resistance are most likely to be found at the geographical center, but there are too many exceptions to this and we can no longer consider it a safe procedure to limit a survey to any particular point of origin.

G. K. Parris found the only known resistance to downy mildew of watermelons to come from Santo Domingo, an area of early cultivation, not from Africa, the center of origin of the genus. Also Dr. D. Reddick found the most abundant source of late blight resistance in potato to come from the highlands of Mexico, a secondary center of origin, rather than from the primary center in South America. Some of the best resistance to root knot of lima beans comes from material furnished by the Hopi Indians of our own Southwest, not from that obtained at the center of origin in Central America and the Caribbean area.

It seems probable, therefore, that our most hopeful source of disease and insect resistance may be centers of early cultivation of the particular crop rather than centers of origin of the genus or species. Many instances of this could be cited. Quite often resistance can be found in primitive types at the center of origin but it can be found also in more advanced horticultural types in some distant center of early cultivation. It is to the advantage of breeders ordinarily to use stocks that are most advanced from a horticultural standpoint rather than to go back to the more primitive types.

It would seem foolish for a tomato breeder to go back to Lycopersicon pimpinellifolium for resistance to Fusarium wilt when we already have near-immunity in commercial types. If a new form of wilt should become epidemic it might be necessary to go back to the primitive types for resistance to it, but in that case one is confronted with an essentially new disease.

Table 2 lists a number of vegetable diseases and insects for which resistance is available in relatively advanced horticultural types and where it is no longer necessary to search among primitive stocks except for the constant hope of finding higher levels of resistance. Many of these advanced types exist only as breeding lines, sometimes in the hands of single individuals. A great present need is to provide for wider knowledge and dissemination of valuable breeding stocks which would in many cases remove the need for primitive types and often enable new projects to start off at a higher level.

There was a day when breeders were jealous of their possessions, but today they are almost universally glad to share with any who can use what they have found. This attitude encourages us to predict a very active period of accomplishment in vegetable breeding in the next several years.

Conclusions

Recent increase in vegetable breeding activity is due in part to the newly realized possibilities in disease and insect resistance.

By not having in mind the whole disease picture a breeder may end up with something that is resistant to one disease but lacking even ordinary tolerance to some other disease.

Disease resistance will accomplish nothing unless the resistant variety has also the other characteristics required for successful cultivation.

It is a characteristic of breeders that they will use a stock more readily after it has been released as a named variety than they will while it exists only as a number in some other breeder's collection.

For maximum results from cooperative research all procedures and concepts must be reduced to their simplest terms.

A minimum rating system for all vegetable diseases is proposed to consist of: 1. Most resistant, 2. Less resistant, 3. Mixed or doubtful, 4. Less susceptible, 5. Most susceptible. A uniform rating chart incorporating this system is proposed for the cooperative appraisal of foreign vegetable accessions.

An accurate assay of disease resistance depends strongly on the level of infection at which the readings are obtained. There is an optimum level of infection for every disease at which the various degrees of resistance are most clearly distinguishable. Breeders should seek this optimum level, and deviations from it should be interpreted cautiously.

It is inadvisable to test the same individual plant for reaction to more than one pathogen because of the interactions that may occur.

One of the best sources of resistant stocks may be centers of early cultivation rather than

Table 2. Resistance available in advanced horticultural types.

Crop	Disease or insect[a]	Available from[b]
Asparagus	Rust (Puccinia asparagi)	Iowa
Bean	Anthracnose (Colletotrichum lindemuthianum), bacterial blight	Cornell
	Curly top (virus), powdery mildew (Erysiphe polygoni), mosaic (virus), rust (Uromyces phaseoli)	USDA
	Root knot (nematode, Meloidogyne sp.)	Alabama
Beet	Curly top (virus)	USDA
Cabbage	Yellows (Fusarium), mosaic (virus)	Wisconsin
Celery	Cercospora leafspot, Septoria leafspot	Cornell
	Yellows (aster yellows virus)	Michigan
Cucumber	Bacterial wilt (Erwinia tracheiphila)	USDA
	Mosaic (virus)	Cornell
	Scab (Cladosporium cucumerinum)	Wisconsin
	Downy mildew (Pseudoperonospora cubensis), anthracnose (Colletotrichum lagenarium)	South Carolina
	Powdery mildew (Erysiphe cichoracearum)	California
Cantaloupe	Aphis	Georgia
	Downy mildew	South Carolina
	Powdery mildew	USDA
	Wilt (caused by Fusarium)	Cornell
Eggplant	Bacterial wilt (Xanthomonas solanacearum)	Puerto Rico
	Phomopsis blight (P. vexans)	Florida
Lettuce	Brown blight, downy mildew (Bremia lactucae), mosaic (virus)	USDA
Lima bean	Root knot (nematode)	Oklahoma
Onion	Downy mildew (Peronospora destructor), pink root (Pyrenochaeta terrestris), smut (Urocystis cepulae), thrips	USDA
Pea	Wilt (Fusarium)	Wisconsin
	Powdery mildew (Erysiphe polygoni)	Idaho
Pepper	Mosaic (virus)	Puerto Rico
Potato	Scab (Streptomyces scabies), hopper burn, late blight (Phytophthora infestans), several virus diseases	USDA
Spinach	Downy mildew (Peronospora effusa), mosaic (virus)	California
Sweet corn	Bacterial wilt (Bacterium stewartii), smut (Ustilago maydis)	Iowa
	Ear worm	USDA
Tomato	Anthracnose (Colletotrichum phomoides), leafmold (Cladosporium fulvum)	Ohio
	Bacterial wilt (Xanthomonas solanacearum), late blight	North Carolina
	Collar rot (Alternaria), curly top (virus)	USDA
	Early blight (Alternaria), wilt (Fusarium), Septoria leafspot	USDA
	Stemphylium leafspot	USDA
	Spotted wilt (virus)	Hawaii
	Verticillium wilt	California
Watermelon	Anthracnose, wilt (caused by Fusarium)	USDA
	Downy mildew	Florida

[a] Resistance to these diseases or insects is highly significant but in most cases a still higher degree of resistance should be sought.

[b] Only one source is given, whereas in most cases there are several sources.

centers of origin of the genus or species.

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TRANSMISSION OF CABBAGE BLACK ROT AT HASTINGS, FLORIDA

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Research has shown that the cabbage black rot organism, Xanthomonas campestris (Pam.) Dowson, is seedborne and that it may live over the winter in diseased crop refuse in northern States (1, 4, 5, 7). Because of this, control measures for black rot in the North consist of use of disease-free or hot-water-treated seed, and rotation of seedbeds or use of new land for production of plants (1, 6). In Wisconsin it is recommended that two to three years elapse between cruciferous crops to control black rot in the field (6). Studies on the transmission of black rot and survival of the causal organism in soil were made at Hastings, Florida, from 1947 to 1951 and the results are reported in this paper.

Relation of Temperature to Development of Black Rot

Cook et al. (2) found that black rot developed rapidly in cabbage plants inoculated with X. campestris and held at 28° C. (82.4° F.) for eight weeks, and it developed slowly or failed to appear in inoculated plants held at 16° C. (60.8° F.). Elliott (3) reported that black rot bacteria grow best at 86° to 88° F., and that the upper limit for growth is 102° F. and the lower, 41° F. Walker (5) observed that external symptoms of black rot disappeared from young plants in Wisconsin if temperatures during the early part of the growing season were low enough to check growth of the causal organism, and that signs of the disease reappeared in infected plants and became epidemic as temperatures rose during the summer.

Black rot developed rapidly and caused excessive losses in affected fields at Hastings during three successive seasons, 1947 to 1950, when seasonal temperatures averaged 62.6° to 67.2° F., (Table 1). It developed slowly and caused little loss in the 1950-1951 season when the average seasonal temperature was 59.3° and monthly temperatures did not exceed 59.9°, except in March.

Since black rot was not so severe in the 1950-1951 season when rainfall totaled 8.95 inches, as it was in the 1949-1950 season when the rainfall was about two inches less, and also in the 1947-1948 season when it was about 13 inches more, it does not appear that seasonal rainfall affected development of the disease.

Table 1. Temperatures, rainfall, and severity of black rot of cabbage at Hastings, Florida during four growing seasons, 1947 to 1951.*

Season	Average monthly temperatures °F.					Average seasonal temperature °F.	Total seasonal rainfall inches	Severity of black rot
	Nov.	Dec.	Jan.	Feb.	Mar.			
	1947			1948				
1947-1948	66.7	60.4	55.2	62.4	68.3	62.6	22.51	Severe
	1948			1949				
1948-1949	71.8	65.5	64.9	67.7	64.3	67.2	10.45	Severe
	1949			1950				
1949-1950	62.4	62.7	67.7	63.9	64.4	64.2	6.88	Severe
	1950			1951				
1950-1951	59.9	54.5	59.3	57.7	64.8	59.3	8.95	Mild

* Temperature and rainfall records were made at Federal Point, Florida, by the U. S. Weather Bureau.

[1] Plant Pathologist in Charge, Potato Investigations Laboratory, Florida Agricultural Experiment Station. Florida Agricultural Experiment Station Journal Series, No. 150.

Survival of the Black Rot Organism in Soil

Test 1 -- In a field in which 90 percent of the cabbage plants were affected with black rot when grown during the fall of 1947, two rows were set to cabbage January 15, 1948, after the fall crop had been cut and the stubble plowed under. On April 14, 10.3 percent of the 546 plants grown were affected with black rot. It is probable that the disease in the spring-grown plants was caused by soil-borne black rot bacteria originating from diseased plants of the fall crop; as the plants set in the infested field in January were grown in the same plant bed and were similar to those which were free of the disease when grown in other fields.

Test 2 -- Cabbage seed soaked 25 minutes in water held at 122° F. was sown in October 1948 in a seedbed which had not been planted to crucifers for several years. In November, about 20 thousand plants grown in this seedbed were set in a commercial field where 98 percent of the plants had been affected with black rot in the spring of 1948. The plants were observed for symptoms of black rot several times from November 1948 to the following March. Only 2 percent were found to be affected with the disease by the time harvesting was completed.

Test 3 -- In 1949 cabbage transplants grown in sterilized soil from hot-water-treated seed were set in Experimental Block 1, where all cabbage plants had been affected with black rot in 1948. Of 240 plants grown in 1949, only 8 percent developed the disease. In 1950, none of 209 cauliflower plants originating from hot-water-treated seed and set in Block 1 and grown to maturity was affected with black rot, thus demonstrating that the disease was not carried over in this soil the second year.

Test 4 -- Cabbage, cauliflower, Brussels sprouts, and rutabaga seeds were treated with hot water and planted November 20, 1950, in soil in which cabbage plants grown the previous year had not been affected with black rot. On January 3, 1951, plants of the four crucifers grown in this seedbed were set in Experimental Block 2 where all cabbage plants had been affected with black rot in 1950. Hot-water-treated cabbage, kohlrabi, and kale seeds also were sown in the infested soil of Block 2 November 1950 and thinned to a stand January 26, 1951. The seedlings, transplanted and thinned plants of the different crucifers were examined for symptoms of black rot but none appeared throughout the growing season (Table 2).

Table 2. Development of black rot in 1951 in different crucifers grown from hot-water-treated seed in soil in which 100 percent of the cabbage plants had been affected with the disease in 1950.*

Crucifer	Number of plants		
	Transplanted	Thinned	Affected with black rot
Cabbage	186		None
Cabbage		97	Do.
Cauliflower	197		Do.
Brussels sprouts	42		Do.
Kohlrabi		50	Do.
Kale		12	Do.
Rutabaga	90		Do.

* All plants grown in this soil in 1950 were inoculated with X. campestris and all developed black rot. The heads were not cut and the plants were disked into the soil before they were destroyed by black rot and soft rot.

Transmission of Black Rot in the Seed

Development of the Disease in Plants Grown from Seed Inoculated with Xanthomonas campestris -- Cabbage seeds inoculated by soaking for one hour in a water suspension of X. campestris, and non-inoculated seeds, were planted November 20, 1950, in soil in which cabbage had been grown the previous year but showed no symptoms of black rot. Hot-water-treated, non-inocu-

lated seeds also were planted in soil in which all cabbage plants had been affected with the disease the year before. None of the seedlings, transplanted, or thinned plants grown from hot-water-treated, non-inoculated seeds showed any symptoms of black rot when grown in either infested or non-infested soil (Table 3). Of the 317 seedlings grown from inoculated seed in non-infested soil, 6.3 percent showed symptoms of black rot when they were examined January 10, 1951. The affected seedlings were pulled and destroyed, and of the 297 plants left, 17.2 percent developed black rot by the end of the growing season.

Table 3. Cabbage seedlings and plants affected with black rot when grown in infested and non-infested soil in 1951 from hot-water-treated seed and treated seed inoculated with X. campestris.

Seed	Soil	Seedlings: Total number	Seedlings: Affected with black rot: Number	Seedlings: Affected with black rot: Percent	Plants: Total number	Plants: Affected with black rot: Number	Plants: Affected with black rot: Percent
						Transplanted	
Treated with hot water	Infested*	954	none	none	198	none	none
	Non-infested**	878	none	none	182	none	none
						Thinned	
Treated with hot water and inoculated with black rot bacteria	Non-infested**	317	20	6.3	297	51	17.2

* All plants grown in this soil in 1950 were affected with black rot. None of the heads were cut and the plants were plowed under before they died.

** None of the plants grown in this soil in 1950 were affected with black rot.

Development of the Disease in Plants Grown in New Land from Non-treated Infected Seed -- In November 1947 at Bunnell, Florida, Oakview Ballhead and Glory of Enkhuizen cabbage plants grown from non-treated seed in newly-cleared land were transplanted to a 10-acre field of new land. Fifty-five percent of the cabbage plants in this field became affected with black rot by the time harvesting was completed.

Forty-eight Oakview and 40 Glory of Enkhuizen plants drawn from the plant bed at Bunnell in December 1947 were transplanted to a Hastings field which had not been planted to cabbage for three years. Eight of the Glory of Enkhuizen plants were affected with black rot when transplanted. Of the 88 plants grown, all became affected with the disease before harvesting was completed; only 21 plants produced marketable heads. Results of this test indicate that the seed was infected or contaminated with black rot bacteria before it was planted. The disease developed in some plants in the plant bed and spread from these to healthy plants in the plant bed and field.

Summary and Conclusions

Black rot became severe in affected cabbage fields at Hastings, Florida, during three seasons, 1947 to 1950, when the average seasonal temperatures ranged from 62.6° to 67.2° F. The disease was mild in affected fields in the 1950-1951 season when the temperature averaged 59.3°. Total seasonal rainfall during the four seasons varied from 6.88 to 22.51 inches; it did not appear to affect the development of black rot.

When cabbage plants were drawn from a plant bed where black rot was known to be present, and transplanted to a 10-acre field of new land at Bunnel, Florida, in November 1947, over one half of the plants became affected with the disease before harvesting was completed in March 1948. The plant bed was located in newly-cleared land. It is probable that the disease originated

from black rot bacteria in or on the seed, which had not been treated with hot water.

In 1949, in a commercial field at Hastings, only 2 percent of the cabbage plants were affected with black rot when grown in a field where 98 percent of the plants had been affected with the disease the year before.

Eight percent of the cabbage plants developed black rot in 1949 when grown from hot-water-treated seed in an experimental block of soil infested with the causal organism the year before. None of the disease appeared in cauliflower plants grown from hot-water-treated seed in this soil in 1950, the second year after it was infested with Xanthomonas campestris.

Black rot bacteria lived from the spring to the following winter in some locations at Hastings, Florida, and infected cabbage plants were grown in the infested land. In other locations either the bacteria did not survive or conditions were unfavorable for them to infect cabbage and other susceptible cruciferous seedlings, transplants, and thinned plants grown during the winter in soil infested the preceding spring.

During the cool season of 1950-1951, black rot developed in some cabbage seedlings and thinned plants grown in non-infested soil from seed inoculated with X. campestris; but the disease did not appear in cabbage seedlings and plants grown from hot-water-treated, non-inoculated seed in non-infested soil and in soil that had been infested with the causal organism by plowing under black rot-affected cabbage plants the preceding season.

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REPRODUCTION OF SYMPTOMS RESEMBLING INTERNAL BROWNING OF TOMATO UNDER GREENHOUSE CONDITIONS

S. P. Raychaudhuri

Internal browning of tomato was reported by Haenseler (4) and Holmes (5) from New Jersey. Similar disorders in tomatoes, namely, vascular browning or gray wall, internal browning or core rot, were described by Lorenz and Knott (7) from California, Young (10) from Texas, Conover (1) from Florida, and Friedman (3) from New York. Recently, Raychaudhuri (8) studied internal browning of tomato in this laboratory[1].

The disease is of fairly widespread occurrence in many States in this country and may cause severe loss to the crop. The growers in New Jersey have reported that the disease usually is associated with high moisture content in the soil. About 20 percent of the fruits examined by the writer in a tomato field in Bridgeton, New Jersey, in 1951 were found severely diseased and most of the diseased fruits were borne by vines that were growing in wet soil.

Although several investigators (2, 6, 8, 9) attempted to reproduce the disease under experimental conditions, all the reports indicated negative results excepting that by Cox and Weaver, who were able to reproduce disease symptoms in some tomato fruits that ripened on grafted plants during November and December; all the fruits ripening thereafter were healthy.

During the course of investigations on this problem, several samples of affected tomatoes were obtained from various sources. In all the specimens received from New Brunswick and Bridgeton, New Jersey, and most of those obtained from Pennsylvania, a strain of tobacco-mosaic virus was found associated with the disorder in the tomato fruits (8). However, certain samples of affected fruits obtained from Pennsylvania were free from viruses, bacteria, and fungi. This observation, coupled with failure of various investigators to reproduce the disease with the virus alone, led the writer to carry out certain physiological experiments.

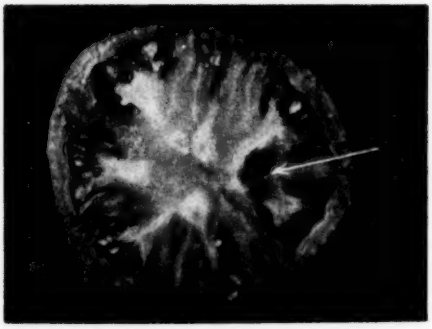

FIGURE 1. Symptoms resembling internal browning are shown by the arrow.

Tomato plants of the variety Bonny Best that were infected with a strain of tobacco-mosaic virus were raised in a greenhouse at 20° to 25° C. The following three treatments were given: (a) plants supplied with additional doses of nitrate (sodium nitrate, 0.2 percent in 200 cc. of water) twice a week; (b) fruits, when about 1 1/2 to 2 inches in diameter, were dipped in water for 4 to 5 days; and (c) plants supplied with additional doses of nitrate as in (a) and fruits dipped in water as in (b). Four of 10 fruits treated as indicated in (c) showed symptoms resembling internal browning (Figure 1). The exterior of the fruits was almost normal or showed a few light yellowish-orange patches on the red skin. They produced hard white corky tissues around the rind. Certain tissues within tomato fruits were dead and brown in color. No bacteria or fungi could be isolated from these tissues. In other experiments, similar to those described above in which the plants were not infected with virus, necrotic lesions typical of internal browning were observed in tomato fruits free of detectable tobacco-mosaic virus.

[1]The author is much indebted to Dr. L. O. Kunkel and Dr. F. O. Holmes for their interest in the work, and to Dr. A. C. Braun for valuable suggestions and helpful criticisms.

Needless to say, the results reported above are preliminary observations. They indicate, nevertheless, that high moisture content of the air which results possibly in water congestion of the tissue of the tomato fruit may be an important factor in the internal breakdown of the tomato tissue. The role of the virus in this disease remains uncertain.

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EFFECT OF SEED TREATMENT ON YIELD AND NODULATION OF SOYBEANS IN MINNESOTA[1]

M. F. Kernkamp, F. I. Frosheiser, and J. W. Gibler[2]

Many investigators have reported increased stands of soybeans from chemical seed treatment (1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 15), and some (5, 6, 7) have been able to demonstrate increases in yield.

At the Minnesota Agricultural Experiment Station seed treatment tests have been made for the past ten years. Greenhouse tests with mechanically injured seed and moldy and weathered seed have given remarkable increases in stands, and have encouraged the writers to believe that under certain conditions seed treatments may be of great value to soybean producers. This paper is a summary of field tests on the effects of seed treatments on yield of soybeans in 1947, 1948, 1949, 1951, and 1952.

Studies also were made of the effect of seed treatment and Rhizobial inoculants when both were applied to the seeds. Five field tests will be reported in which nodulation was recorded following seed treatment and inoculation.

All of the treatments were planted in randomized blocks with three or four replications, except in 1949 when there were six. Fungicides that were known to cause injury to seedlings when used in excessive dosages were applied at recommended rates; those that would not injure seedlings were applied at excessive rates. Fungicides were usually applied several days to several weeks in advance of planting. Planting rates were adjusted to fit the experiment, but unless otherwise stated, the planting rate was 60 pounds per acre in rod rows spaced 30 inches apart.

The fungicides, rates of application, rates of planting, and yield data appear in Tables 1 and 2. All yields are recorded in bushels per acre, and yields that were significantly different from the check are indicated.

Table 1. Yields from soybeans treated with six fungicides in 1947, 1948, 1949, 1951. Experiments in Minnesota.

Fungicide	Rate of application oz. per bushel	Yields (bu. per acre)[a] 1947	1948	1949	1951
Spergon	Excessive dosage	32.2	25.2	18.8	20.1
Semesan Jr.	2	30.4	23.4	21.2	--
New Improved Ceresan	1/2	34.0	23.8	19.1	--
Ceresan M	1	--	--	19.3	--
Red Cuprocide	2	--	--	20.3	--
Arasan	Excessive dosage	--	--	20.4	18.8*
Control		34.0	23.1	17.7	21.4

[a] Averages of 4 replications in 1947, 1948, and 1951, and averages of 6 replications in 1949.

* Significant at the 5% level.

It is evident from Table 1 that there was only one yield significantly different from the check, and that was a statistically significant reduction in yield in 1951 from Arasan-treated

[1] This work was done in cooperation with the Division of Forage Crops and Diseases, United States Department of Agriculture. Paper No. 2972 of the Scientific Journal Series of the Minnesota Agricultural Experiment Station.

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Table 2. Yield of soybeans from treated seed planted at 20, 40, and 60 pounds per acre in 1951 and 1952. Experiments in Minnesota.

Fungicides and rate of application per bushel	Rate of planting in pounds per acre and yields in bushels per acre					
	1951			1952		
	20	40	60	20	40	60
Arasan SF 2 oz.	15.6	19.4	20.6	28.1	33.9	31.4
Arasan SF 5 oz.	18.2	19.6	21.5	27.8	32.7	32.6
Vancide 51 136 cc.	17.0	19.1	19.9	25.3	32.3	30.1
Vancide 51 272 cc.	17.7	21.8*	22.3	27.3	30.3	31.9
Spergon 2 oz.	17.8	21.0	21.3	29.2	31.4	31.9
Spergon 5 oz.	19.1	21.6	21.4	26.4	32.9	32.0
Control	17.9	17.8	21.1	30.3	29.5	30.9
Means	17.6	20.1	21.1	27.8	31.8	31.5

* Significant at the 5% level.

seeds. The reason for that is unknown, but it is of little importance at any rate because there was no significant differences for the means of the four years.

In the tests reported in Table 1, there was usually an increase in stand for all treatments over the check. The results indicated that the heavy rate of planting overshadowed increases in stand from treatment. It seemed, therefore, that to demonstrate any increases in yield from seed treatment, it would be necessary to reduce the planting rate. Therefore, an experiment was designed in which treated seed was planted at rates of 20, 40, and 60 pounds per acre in rod rows spaced 30 inches apart. The test was planted in a randomized block design, replicated three times in 1951 and repeated in 1952. The data from these tests are recorded in Table 2, and they were analyzed by the Analysis of Variance method.

There were no significant increases in yield from seed treatment, except in the one treatment indicated. However, the results are interesting as far as planting rates are concerned. The yields from different planting rates were not significantly different, although the 20-pound rates gave inferior yields in both years. There was no appreciable difference between the 40- and 60-pound rates. In Minnesota rates of 75 or more pounds per acre are recommended. These results indicate that seeding rates could be reduced without jeopardizing yields.

While these tests were being made data were accumulated on the influence of chemical seed treatments on nodulation by Rhizobium leguminosarum Frank emend. Baldwin & Fred. Nodules were counted on the roots of representative numbers of plants picked at random from each plot. The treatments for these tests comprised fungicides alone, fungicides plus inoculum, inoculum alone, and a nontreated non-inoculated control. Data were collected on this phase of the work in the 1947, 1948, and 1951 yield trials. Two additional tests were planted in 1952 and will be discussed separately because of special circumstances. Table 3 gives the treatments and nodulation per plant that developed in the five field tests.

In 1947 and 1948 an effort was made to plant the tests on ground that had never produced soybeans before in order to give the inoculum an opportunity to express itself. Apparently there were nodule bacteria in those fields prior to inoculation and planting, because none of the treatments had any effect on the results. In 1951 the test was planted in a field that had produced soybeans in 1949 and wheat in 1950. As in 1947 and 1948, the treatments had no effect on the results.

In 1948, the senior author (8) reported that treating soybean seed had no effect on nodulation providing the seed was planted in soil that had a sufficiently high population of Rhizobium, but nodulation was reduced on plants from chemically treated seed planted in autoclaved soil. Tests were made to determine if the results would be the same in the field.

The conditions of the 1947, 1948, and 1951 tests satisfied the requirements of soils with

Table 3. The average number of nodules on individual soybean plants grown from seed treated with various fungicides and inoculated with Rhizobium leguminosarum in five field tests in Minnesota.

Treatment	Average number of nodules per plant				
	1947	1948	1951	1952	
				LeSueur	Grand Rapids
Spergon	1.8	3.0	5.1	0.3	0
Spergon + Rhizobium	1.7	2.1	5.1	2.4	0
New Improved Ceresan	1.9	2.9	-	-	-
New Improved Ceresan + Rhizobium	1.8	3.5	-	-	-
Semesan Jr.	1.7	2.2	-	-	-
Semesan Jr. + Rhizobium	1.8	4.1	-	-	-
Arasan	-	-	5.5	0.3	0
Arasan + Rhizobium	-	-	5.7	3.5	2.5
Rhizobium	1.8	4.0	5.0	4.8	2.6
Control	1.7	4.7	5.7	0.1	0

Rhizobium in them, but did not satisfy the requirements of soils with little or no Rhizobium. Therefore, in 1952, two fields were picked with very light sandy loam soils, one at LeSueur, Minnesota and the other at the Grand Rapids Experiment Station, Grand Rapids, Minnesota. In the latter location, soybeans are rarely grown. Presumably the soils at those locations had a relatively low population of Rhizobium and would be comparable to autoclaved soil.

The results of the tests for 1952 (Table 3) bear out the greenhouse results reported earlier (8). The soil at Grand Rapids apparently was devoid of all Rhizobia because none of the non-inoculated treatments had nodules. At that station Spergon prevented nodulation even though Rhizobium was applied to the seed, but Arasan had no effect. At LeSueur the results were similar, but there was some Rhizobium in the soil, each non-inoculated treatment having at least a few nodules. Arasan depressed nodulation slightly, and Spergon depressed nodulation more when used with Rhizobium.

These results, in addition to agreeing with those from greenhouse tests (8), also corroborated to some extent the conclusions reached by Ruhloff and Burton (14), who reported that some chemicals were more effective against Rhizobium spp. than others. They also stated that there was less survival of bacteria in dry soil than in wet soil. The former conditions prevailed in the test at Grand Rapids, where it was extremely dry at the time of planting and remained so for three weeks subsequent to planting.

These results point out the danger of planting chemically treated and Rhizobium-inoculated seed in soils that have a small population of Rhizobium. However, the writers had difficulty in locating such a field in the soybean-producing area of Minnesota, and it is not likely that a grower will plant soybeans on such soils in Minnesota.

SUMMARY AND CONCLUSIONS

Stands of soybeans have been increased consistently by chemical seed treatment in greenhouse tests, especially when the seeds are mechanically injured, moldy, badly weathered, or planted in soil infested with one or more soil-borne pathogens. Similar effects can be demonstrated in field tests. Rarely, however, did increased stands produce increased yields. The results from six field tests do not justify the recommendation that soybean seed should be treated in Minnesota. However, the seed was always protected to some extent, as indicated by increased stands, and was injured only once in these tests. In view of these results, a grower may want to treat the seed for the added protection derived from seed treatment.

If the grower wishes to treat the seed, it appears reasonably safe to use the chemical seed treatment in combination with Rhizobium leguminosarum, providing he plants the soybeans in soil that has an adequate population of Rhizobium. However, in these tests the addition of Rhizobium had no effect on nodulation so that it is difficult to justify the recommendation that bacterial inoculum should be used.

If soybeans are planted in ground that has never produced the crop, it appears that the best practice is to use the inoculant and dispense with seed treatment.

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REACTION OF WINTER OAT VARIETIES AND SELECTIONS TO SOIL-BORNE VIRUSES IN SOUTHEASTERN UNITED STATES[1]

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The soil-borne viruses, Marmor terrestre var. typicum and M. terrestre var. oculatum, were first observed on oats in the United States in 1943[3] at the Alabama Agricultural Experiment Station plots at Auburn. Since that time they have been observed at several locations in North Carolina, South Carolina, Georgia and Alabama. The actual loss resulting from this disease has never been determined; however, susceptible varieties often fail to produce seed when they are grown in infested soil.

Materials and Methods

The data reported were obtained from several sources and supplement those previously published[4]. The data in Table 1 were recorded by H. H. McKinney from duplicate nurseries grown at Statesville, North Carolina, Clemson and York, South Carolina, and Experiment, Georgia in 1949. The nurseries were grown again at the same locations in 1950, but at Clemson insufficient mosaic developed for making readings. U. R. Gore made the readings on the nurseries in Georgia. The readings on the nurseries in the Carolinas were made by McKinney in 1949, and by the senior author thereafter.

The seed for the U. S. Department of Agriculture Uniform Winter Oat Nurseries was obtained from F. A. Coffman. The data for 1951 are from the nursery at Statesville, North Carolina. Data from the nursery at Experiment, Georgia was combined with that at Statesville in 1952. Two replications of each nursery were grown in both years. If an entry was in more than one nursery only the maximum reading from all nurseries is given.

The information in Table 3 is from observations made at various times by the authors. The varieties listed are those recommended by the Experiment Stations in Virginia, North Carolina, South Carolina, Georgia, Tennessee and Alabama in 1952.

The reactions were recorded on the basis of the percentage of the plants showing symptoms of the disease with the severity of the reaction also included in most instances. Recommendations with respect to growing the variety or selection in soil known to be infested with the viruses are given in the last column.

Results

Several varieties now used in oat breeding in the United States are included in Table 1. Of the four varieties Ukraine, Landhafer, Santa Fe, and Trispernia used as sources of crown rust (Puccinia coronata) resistance, only the latter was resistant to mosaic. In 1950-51 it appeared that some Santa Fe and Landhafer plants were resistant to the viruses but the progeny rows from those plants were winter killed in 1951-52. Separate 2 of Santa Fe, C. I. 4519, was more resistant than separate 1, C. I. 4518. As a group the Anderson and Marett selections were very resistant, as in earlier tests. In some cases the Victorgrain and Fulgrain strains and derivatives were not so resistant as they had appeared to be previously. The two halo blight (Pseudomonas coronafaciens) resistant Karella selections were very susceptible and they rosetted.

The reaction of the important varieties grown in other areas in the winter oat belt, and advanced lines from which will probably come the next varieties for the region are included in Table 2. Mustang, a variety that is outstanding in the western portion of the region, was one of the most susceptible varieties tested. A sister selection of Mustang, C. I. 6571, was somewhat resistant. Most of the hybrids derived from Bond, Bonda, and Colo were susceptible. The varieties Arlington and Atlantic, now widely grown in the southeastern United States, re-

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[1] Cooperative investigations between the Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture, and the Agricultural Experiment Stations of Georgia, North Carolina, and South Carolina.

[2] We wish to express our appreciation to F. A. Coffman and T. R. Stanton of the Division of Cereal Crops and Diseases for supplying seed of some of the varieties and selections of oats used in these studies.

[3] McKinney, H. H. 1946. Mosaics of winter oats induced by soil-borne viruses. Phytopathology 36: 359-369.

[4] _____, et al. 1949. U. S. Department of Agriculture Circ. No. 809, 17 p., 5 figs. June.

Table 1. Reaction of varieties and selections of oats grown in cooperative oat mosaic nurseries from 1949 to 1952.

C. I. No.	Variety or selection	Maximum percent mosaic[a] 1949	1950	1951-52	Recommendation[b]
3259	Ukraine	--	100 VS	--	NR
3522	Landhafer	--	100 VS	--	NR
4009	Trispernia	--	15 M	Tr	R
4473	Letoria x Fulwin	50 M	40 M	10	R
4474	" "	5	5 VM	Tr	R
4480	" "	10 M	40 M	5	R
4487	" "	80	80 VM	5	R
4488	" "	80	80 VM	5	R
4489	" "	35	15	5	R
4518	Santa Fe (Sep. 1)	--	90 S	100 S	NR
4519	" (" 2)	--	60 S	10 S	NR
4685	Victorgrain (1947 Sales Stock)	90 VM	10 M	5	R
4722	Red Algerian	--	80	--	NR
4842	Hobson	5 S	35 S	70 S	NR
4844	Botler	50 S	60 S	80 S	NR
4845	Nelson	90 S	100 S	80 S	NR
4846	Olney	Tr M	25 M	20	R
4853	D69-Bond x Iowa Winter 8 (x-10-1-8)	M	25 M	20	R
4855	Lee x Bond-Iogold	--	100 S	70 S	NR
4862	Stanton 40-33 x Fulgrain 3	Tr	10 VM	5	R
4863	" " "	Tr	10 VM	5	R
4876	Red Rustproof 14	5	5 M	5	R
4878	Fulwin x Iogold-Bond	Tr	50 Seg.	2 VM	R
4993	Tenn. 1922 x (Bond-Iogold)	50 MO	100 S	80 S	NR
5114	Victorgrain (1949 BFS)	10 M	5 M	5	R
5115	Fulgrain (1949 BFS)	10 M	5 M	10	R
5119	Marett Winter Resistant 6	0	0	5	R
5120	Anderson Sel. (H82-2-10-x-6)	Tr	10 M	5	R
5121	" " (" -3-1)	0	5 M	Tr	R
5122	" " (" -3-6)	2 VM	5 M	Tr	R
5123	" " (" -12-1)	2 VM	5 M	Tr	R
5124	Carolina Red x Winter Resistant 5	0	Tr	Tr	R
5125	(Fulgrain 4-Lega) x (Victorgrain-Appler)	10 M	20 M	5	R
5127	C.I. 4854 Resel. C.I. 4833-Tenn. 1922 x (Bond-Iogold)	35 MO	25 S	10	R
5129	Stanton 40-33 x Fulgrain 3	5	25	20	R
5130	C.I. 4863 (Stanton x Fulgrain 3)	Tr	15	5	R
5131	(Bond-Fulghum) x (Victorgrain 43-6)	5	5	Tr	R
5134	(Bond-Fulghum) x (Victorgrain 43-12)	30 M	50 VM	10	R
5135	" " x " "	50	10 VM	10	R
5136	" " x " "	50	10 VM	5	R
5137	" " x " "	2	5 VM	Tr	R
5138	(Hancock x Morota-Bond) x Victorgrain	5	25 Seg.	5	R
5142	(Green Russian-Bond) x Fulgrain 4	20	20 M	Tr	R
5143	" " "	10 M	10 M	Tr	R
5145	Fultex-RRP x Victoria-Richland	50 S	100 S	50 M	NR
5148	(Tennex-RRP) x (Victoria-Norton)	Tr	20 M	5	R
5152	(" ") x (" -Richland)	Tr	10 M	5	R
5340	Kareela Sel. (Resistant to halo blight)	--	100 S	100 S	NR
5341	" " " " " "	--	100 S	100 S	NR
5344	Arkansas 160 (Winter Fulghum Type)	--	30 S		R
5348	Hancock x (Morota-Bond) x Victorgrain (Coker 49-25)		50 S		NR
5349	RRP x (V-R) x Fultex (Resel. C.I. 4869) (Coker 49-45)		100 S		NR
5350	" " (Resel. C.I. 4869) (Coker 49-46)		100 S		NR
5351	" " (Resel. C.I. 4869) (Coker 49-47)		100 S		NR
5353	Victorgrain (1950 BFS)		50 M		R
5354	" (Coker 48-88)		Tr		R
5356	Fulgrain (1950 BFS)		10 S		R
5357	" (Coker 48-107)		10 S		R
5358	Anderson (Marett 48-161)		5 M		R
5359	" (Marett 48-216)		Tr		R
5360	" (Marett 48-235)		Tr		R
5361	" (Marett 48-414)		Tr		R
5362	Marett Hybrid Sel. 1 0-132-Carolina Red x Fultex-Victorgrain		Tr		R

[a]The severity of the reaction is as follows: VM=very mild; M=mild; MO=moderate; S=severe; VS=very severe; Seg.=indicates that the strain is segregating for mosaic reaction; tr.=a trace of mosaic or less than 2 percent.

[b]The letter R signifies that the variety can be recommended in fields known to be infested with the viruses; the letters NR signify that the variety should not be recommended in those fields.

Table 2. Reaction of entries in the U. S. Department of Agriculture uniform winter oats nurseries to mosaic in 1951 and 1952.

C. I. No.	Variety or selection	Maximum percent mosaic[a] 1951	Maximum percent mosaic[a] 1952	Recommendation[b]
947	Tech	100 S	90 S	NR
2499	Fulghum (Winter Type) (Pentagon)	10	10	R
4476	Letoria x Fulwin N. C. 4289	Tr	60	NR
4600	Coy	40	Tr	R
4653	Delair	Tr	10	R
4660	Mustang	100 VS	100 VS	NR
4829	Woodward Composite	5	5	R
4834	(Fulwin x Tennex) x Bond Tex. Sel.	70 M	5	NR
5106	Woodward Sel. 472606	5	10	R
5118	Colo x Wintok	100	90	NR
5153	Bond x Winter Oat	40	--	R
5207	Southland	40	20	R
5352	(RRP x Victoria-Richland) x Fultex Cokers 49-49	70	100 M	NR
5364	New York Sel. Cornell No. 1375	90	80	NR
5366	Wintok x Colo	10	--	R
5367	Bond x Winter Oat	60	--	R
5368	Clinton x Hairy Culberson	100	90	NR
5369	" x Forkedeer	10	70	NR
5370	(D69-Bond) x Fultex: Tex. Sel.	100	--	NR
5371	(Victoria x Hajira-Banner) x (Fulghum-Victa.)	100	100 VS	NR
5372	(RRP x Victoria) x Norton: Ga. H842	10	100 S	NR
5373	Bond x Winter Oats	70	--	NR
5374	" x " "	80	--	NR
5375	Colo x Wintok	100	--	NR
5376	Bond x Winter Oat	20	--	R
5377	Bond x Winter Oat	20		R
5378	(Lee-Vict. x Ful.) x C.I. 4189	20		R
5379	" " " x "	20		R
5380	Fulwin x (Lee-Vict.): C.I. 4382 x Bonda Sel. 5577	100 S		NR
5381	" " " C.I. 4382 x Bonda Sel. 5578	100 S		NR
5382	Colo x Wintok	100 S		NR
5383	Wintok x Colo	100 S		NR
5471	Winter Turf x (Clinton 2 x Santa Fe) Sel. 2802	10		R
5497	Atlantic x (Clinton 2 x Santa Fe) Sel. 2882	10		R
4652	Taggart	0		R
5847	Fulgrain 1951 BFS	10		R
5848	(Lee-Vict.) x Forkedeer Ind. Sel. A392	10		R
5849	Wintok: Sel. 492825	0	10	R
5850	Arkwin: Tenn. 1922 x (Bond x Iogold) Ark. Sel.	10	25 M	R
5872	Nortex: Stoneville Pedigreed Seed Co. Sel. 0112	2	20	R
5873	C.I. 4019 x (Fulghum x Victoria) Stuttgart, Ark. Sel.	100 S	100 VS	NR
5874	Fulwin x D69-Bond: Sel. 120-46-20	10	100 M	NR
5875	" x (Lee-Victoria) x Bonda Sel. 5527	80 S	100 VS	NR
6570	Winter Fulghum: Okla. Sel. 462567		10	R
6571	Fulwin x (Lee-Victa.): Tex. Sel. 3770-7		100 S	NR
6572	Clinton x Forkedeer Sel. 4011-4-92		100 S	NR
6573	(Fulwin x Lee-Victa.) x Tennex. Ky. 49-1593		10	R
6574	(C.I. 4383 x C.I. 4189) x Landhafer: Sel. 895-3		100 VS	NR
6575	(C.I. 4658 x (Clinton 2 x Santa Fe): Sel. 506-2	50		R
6576	Atlantic x (Clinton 2 x Santa Fe): Sel. 170-6-4		90 S	NR
6577	Coker's 51-1: (Bond-Fulghum x Victorgrain)		2	R
6578	" 51-2: " " "		Tr	R
6579	Appler x Trelle Dwarf: Stoneville Sel. 24893		30	R
6580	Trispernia x (Clinton 2 x Santa Fe): Sel. 2819-1		10	R
6581	Fla. 167 x Landhafer: Fla. Sel. 2313		50	R
6582	Trispernia x (Clinton 2-Santa Fe): Sel. 2819-3		Tr	R
6583	C.I. 4658 x (Clinton 2-Santa Fe): Sel. 506-1		40	R
6584	Woods Fulwood		Tr	R

[a]See Footnote 1, Table 1
[b]See Footnote 2, Table 1

Table 3. Reaction to mosaic of varieties of winter oats recommended in the southeastern United States in 1952.

C. I. No.	Variety	Recommended by	Maximum percent mosaic[a] 1951		Maximum percent mosaic[a] 1952		Recommendation[b]
2042	Lee	Va.	60		80		
3170	Forkedeer	N. C., Va., Ga., Tenn.	Tr		2		R
3392	Letoria	Va.	100	S	100	S	NR
3855	Stanton 1	Va., Tenn.	100	S	100	S	NR
3923	DeSoto	Ala.	5		50	M	R
4080	Lemont	N. C.	30		10		R
4313	Carolina Red	S. C.	10		100	VM	R[c]
4599	Atlantic	N. C., Va., Ga.	5		2		R
4657	Arlington	N. C., Va., S. C. Ga., Ala.	5		Tr		R
5107	LeConte	Tenn.	10		10		R
5355	Victorgrain 48-93	N. C., S. C., Ga., Ala.	10		10		R
6585	Fulgrain '52 BFC	N. C., S. C., Ga., Tenn.			100	VM	R[c]
--	Anderson	Ala.					R[d]
--	Terruf	Ga.	0		0		R

[a]See Footnote 1, Table 1.
[b]See Footnote 2, Table 1.
[c]Although 100 percent of the plants showed the virus symptoms, the symptoms were very mild.
[d]There are a number of selections and strains of this variety. They are all highly resistant.

sulted from a cross of the same varieties that produced Mustang, yet they are highly resistant.

The reactions of the varieties recommended by the Agricultural Experiment Stations for growing in the States of Virginia, North Carolina, South Carolina, Tennessee, Alabama, and Georgia are given in Table 3. The two varieties Letoria and Stanton, developed in North Carolina and South Carolina, respectively, are not being recommended in those States, partly because of their susceptibility to mosaic. They are still recommended in States farther north where mosaic has not been observed. The two varieties, Carolina Red and Fulgrain BFS 1952, had 100 percent very mild infection in 1952 in one nursery where the level of infection was unusually high. Since these varieties have been moderately resistant in several other tests, it is very unlikely that their yield would be reduced unless the level of viruses is much higher than in most fields.

Conclusions and Summary

Mosaic of oats has not caused much loss in recent years. As mentioned above, two varieties developed in the Carolinas are not being recommended in those States in 1952 but are recommended farther north in States where mosaic has not been observed. The varieties now recommended in the States where the viruses are known to be present are resistant. As long as only resistant varieties are grown there is little possibility of the disease becoming important. Since there are numerous sources of resistance, and the methods of testing for resistance are well established, it should not be necessary to recommend varieties susceptible to mosaic.

COOPERATIVE INVESTIGATIONS BETWEEN THE DIVISION OF CEREAL CROPS AND DISEASES, BUREAU OF PLANT INDUSTRY, SOILS AND AGRICULTURAL ENGINEERING, U. S. DEPARTMENT OF AGRICULTURE, AND THE GEORGIA, NORTH CAROLINA, AND SOUTH CAROLINA AGRICULTURAL EXPERIMENT STATIONS

RESPONSE OF FLAX VARIETIES TO SEED TREATMENT[1]

R. E. Atkins and C. S. Reddy[2]

The value of seed treatment for successful flax production has been demonstrated in many experiments. Flax growers have found the use of New Improved Ceresan or Ceresan M to be a profitable investment and many progressive growers include seed treatment as a "must" in their flax program. As additional seed treatment compounds are developed and improved varieties released continued testing is necessary if accurate recommendations are to be made. Results reported herein were obtained from several Iowa locations during the three year period 1950-1952.

EXPERIMENTAL PROCEDURE

A total of ten replicated experiments were planted at central and northern Iowa locations during the combined 1950-52 seasons. Tests were located in central Iowa at Ames and in northern Iowa at Kanawha, Primghar, Marcus, and Sanborn. A split-plot design was used for each experiment with varieties as the whole-plots and seed treatment compounds as the sub-plots. Three or more replicates were harvested at each location each year. Varieties tested were Redwood, Marine, B5128, Dakota, C.I. 1138, Victory, Minerva, Redwing, Bison, and Koto. Seed treatments used were Ceresan M at a one ounce per bushel rate in all three seasons, Panogen (1.4% mercury) at a one and one-half ounce per bushel rate in 1950 and 1951, and Panogen (1.5% mercury) at a two ounce per bushel rate in 1952. Sowing rate was on a basis of 900 viable seeds per 15 foot row, or approximately three pecks per acre. Data reported and conclusions presented are for seed yield only.

EXPERIMENTAL RESULTS AND CONCLUSIONS

Differences among varieties reached statistical significance in all but one of the ten experiments. Treatment differences exceeded the 1 percent level of probability in only four experiments but treatment means were in favor of Ceresan M in seven of the ten tests. Panogen-treated plots were significantly better than Ceresan-treated plots in only one experiment. Treated plots were significantly higher yielding than non-treated plots in seven of the ten tests.

The average acre yield associated with Ceresan and Panogen seed treatment for the ten varieties in ten tests at five Iowa locations, 1950-52, is given in Table 1.

Panogen did not prove superior to the Ceresan M treatment during the three year period and probably was somewhat less effective in increasing yields. Application rates used in these experiments make Panogen more expensive than the Ceresan M treatment. Other experiments indicate that Panogen can be equal to the Ceresan M treatment if the dosage is increased, but a corresponding increase in cost results. The percentage yield increase from both treatments in comparison with the non-treated plots was sufficient to justify treatment.

Differential response of varieties to seed treatment was apparent. Greatest increase in yield was exhibited by the yellow seeded variety Minerva, with Koto giving next greatest response. The new Redwood variety returned a good yield increase from both treatments. The early maturing varieties Marine and Redwing gave the smallest increases from treatment.

Average yields from the treated and non-treated plots for each of the three seasons are shown in Table 2.

Plots treated with Ceresan M yielded somewhat more than Panogen treated plots in 1950 and 1952, while both had identical average yields in 1951. Average percentage increase of treated versus non-treated plots was of similar magnitude for the three seasons.

IOWA AGRICULTURAL EXPERIMENT STATION, AMES

[1]Contribution from the Agronomy and Botany and Plant Pathology Departments of the Iowa Agricultural Experiment Station, Ames, Iowa. Journal paper No. J-2263 Project 1172.
[2]Associate Professor of Farm Crops and Professor of Botany and Plant Pathology.

Table 1. Average yield in bushels per acre associated with Ceresan and Panogen seed treatment for ten flax varieties grown in ten tests at five Iowa locations during the three-year period 1950-1952.

Treatment	Redwood	Marine	B5128	Dakota	C.I. 1138	Victory	Minerva	Redwing	Bison	Koto	Average	Percent of non-treated
Ceresan M	22.6	20.9	21.4	20.3	20.7	20.4	21.2	18.2	18.8	19.5	20.4	107.4
Panogen	22.1	20.3	21.0	20.1	19.5	19.8	19.7	17.9	18.2	19.9	19.8	104.2
No treatment	20.9	20.4	20.3	19.4	19.0	18.9	18.3	17.8	17.8	17.7	19.0	

Table 2. Average annual yield in bushels per acre associated with Ceresan and Panogen seed treatment for ten flax varieties grown in ten tests at five Iowa locations during the three-year period 1950-1952.

Treatment	1950	1951	1952	3-year average 1950-52	Percent of non-treated, 3-year average 1950-52
Ceresan M	29.0	14.3	17.9	20.4	107.4
Panogen	27.5	14.3	17.7	19.8	104.2
No treatment	26.5	13.6	16.8	19.0	

EFFECT OF SUMMER FUNGICIDES ON THE FINISH OF RUSSET-SENSITIVE APPLES

Eric G. Sharvelle

During the past two years several hitherto unimportant diseases have caused concern to commercial apple growers in southern Indiana. The apparent increase in the incidence of summer diseases such as black pox (Helminthosporium papulosum), black rot (Physalospora obtusa), sooty blotch (Gloeodes pomigena) and Botryosphaeria rot (Botryosphaeria ribis) has necessitated reconsideration of fungicidal materials for the prevention of summer diseases of apples.

Lewis and Shay[1] reported the results obtained with a new fungicide for the control of summer apple diseases in Indiana in 1952. These orchard trials demonstrated the effectiveness of "captan" (Orthocide "406" = n-trichloromethylthio tetrahydrophthalimide) for preventing orchard and post-harvest losses from summer apple diseases. This report is concerned with the effect of captan on the finish of russet-sensitive varieties and supplements the report of Lewis and Shay.

In 1952, different summer spray programs were applied to commercial plantings of russet-sensitive varieties in three locations in Indiana. At harvest time fruit from the different spray plots was graded into arbitrary russet categories based on the percentage of the fruit surface involved by the russet condition. No attempt was made to distinguish between the various types of fruit russet, and the enlarged lenticel condition found on Golden Delicious was included as a type of russet condition. The results of this study are summarized in Table 1.

Table 1. Summary of the effect of "captan" on the finish of Golden Delicious and Grimes Golden apples in southern Indiana.

Orchard	Variety	Spray program[a]	Total number fruits examined	Percent of fruit in various russet categories[b]			
				Russet-free	1-10 %	11-30 %	Over 30%
Purdue (Lafayette)	Golden Delicious	Magnetic "70" sulfur	869	1.9	38.5	57.5	2.3
		Captan 50W (2-100)	944	13.8	65.0	21.2	0.0
Purdue (Bedford)	Golden Delicious	3/4-1 1/2-100 bordeaux and ferbam	1268	12.0	31.0	43.0	14.0
		Captan 50W (2-100)	1738	70.0	21.0	9.0	0.0
Wesley Davis	Golden Delicious	Home-wet sulfur	596	0.3	21.9	36.6	28.2
		Captan 50W (1-100)	525	95.2	3.6	0.8	0.2
		Captan 50W (1-100) from first cover spray	435	16.9	64.4	13.3	0.0

[a] All plots received uniform spray treatment up to petal-fall spray. Spray program indicated applied from petal-fall through sixth cover spray.

[b] Categories refer to percentage of fruit surface involved by russet. Russet of all types including enlarged lenticels considered in grading fruit into the various russet categories.

[1] Plant Disease Reporter 37:84-87. February 15, 1953. Control of summer diseases of apples.

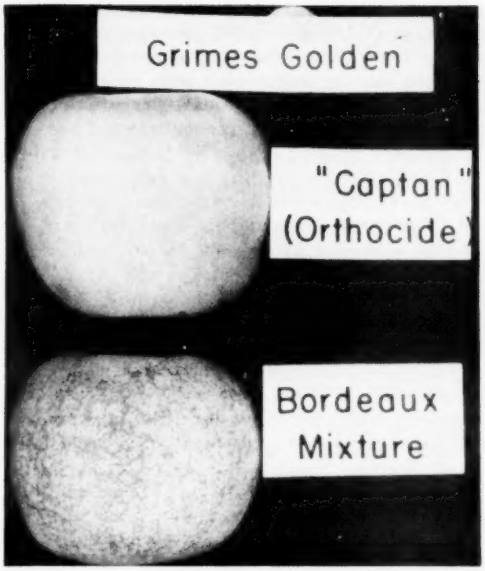

FIGURE 1. Comparison of Grimes Golden apples sprayed in 6 cover sprays with "captan" (2 lbs.-100 gallons) and fruit sprayed with 1-2-100 bordeaux in 1st, 2nd, and 3rd cover sprays and 3/4 lb.-100 gallons of ferbam in 4th, 5th and 6th cover sprays.

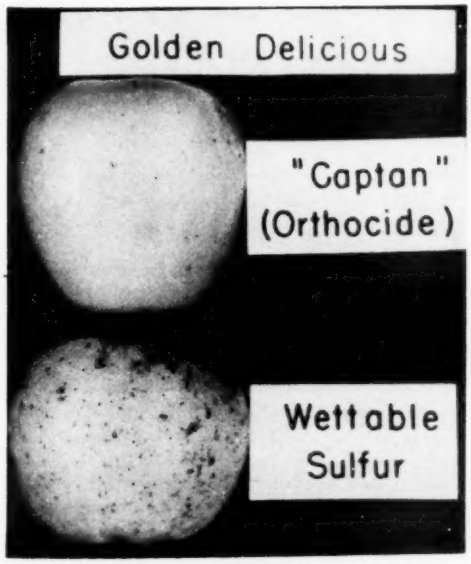

FIGURE 2. Comparison of Golden Delicious apples sprayed with "captan" 1 lb.-100 gallons), lead arsenate and DDT in cover sprays, and fruit sprayed with home-wet sulfur, lead arsenate and DDT in all cover sprays.

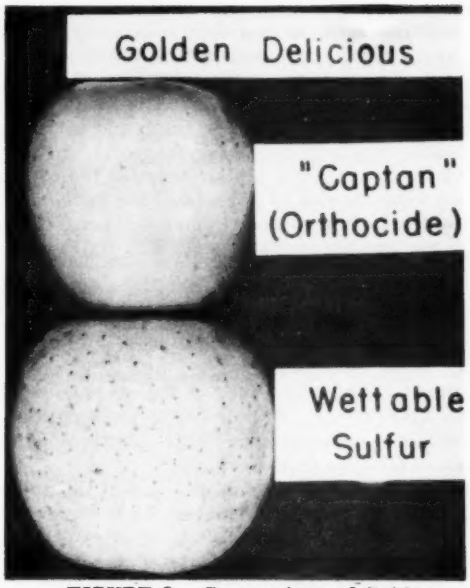

FIGURE 3. Comparison of Golden Delicious apples sprayed with "captan" (2 lbs.-100 gallons) lead arsenate, parathion and DDT in cover sprays and fruits sprayed with Magnetic "70" wettable sulfur, lead arsenate, parathion and DDT in cover sprays.

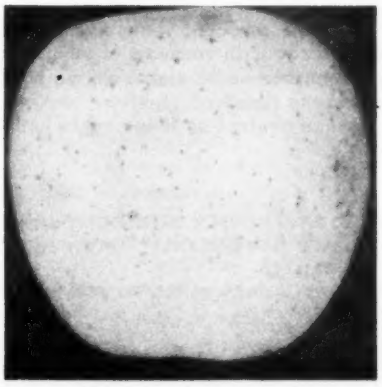

FIGURE 4. Enlarged lenticels on Golden Delicious apples sprayed with ferbam in cover sprays.

In the Purdue orchards at Lafayette, Indiana, a block of the variety Golden Delicious received a uniform fungicide treatment of liquid-lime sulfur (1 1/2 gals.-100 gals.) in the pre-bloom sprays followed by a wettable sulfur program during bloom. Starting at petal-fall part of the block was sprayed with Magnetic "70" sulfur paste and the remainder with captan 50W at 2 pounds in 100 gallons. The fungicides were combined with lead-arsenate, parathion and DDT, and were continued up to and including the sixth cover spray. At harvest time 2 percent of the fruit receiving Magnetic "70" sulfur was entirely free of russet as compared with 14 percent for the captan-sprayed fruit. The U. S. Federal apple grading law permits a russet tolerance of 10 percent of the surface area for U. S. Fancy grade in varieties such as Golden Delicious and Grimes Golden. On this basis 79 percent of the captan-sprayed fruit in the Purdue orchard graded U. S. Fancy as compared with only 41 percent for the sulfur-sprayed fruit.

In the Purdue Orchard at Bedford, Indiana, a block of Grimes Golden received a uniform fungicide application of liquid lime-sulfur in the pre-bloom period followed by wettable sulfur during full bloom. At petal-fall, part of the orchard was sprayed with 3/4-1 1/2-100 bordeaux up to the third cover spray, and then ferbam (3/4-100) in the fourth, fifth, and sixth cover sprays. The remainder of the orchard received captan 50W, (2-100) from petal-fall through the sixth cover. In both cases the fungicide was combined with parathion and DDT. From the results summarized in Table 1, it is apparent that the use of captan greatly improved the finish of Grimes Golden apples.

With this variety 91 percent of the captan-sprayed fruit was graded U. S. Fancy as compared with 44 percent for the fruit receiving the bordeaux fungicide program.

In the third location, the Wesley Davis Orchard, at Clayton, Indiana, a spray program of home-wet sulfur from petal-fall through the cover sprays was compared on Golden Delicious with a captan program at the rate of 1 lb. captan 50W per 100 gallons, instead of the recommended rate of 2 pounds-100 gallons. Even at this reduced rate of application 98 percent of the captan-sprayed fruit was graded U. S. Fancy as compared with 28 percent for the home-wet sulfur schedule. When the captan applications were delayed until first cover spray, the beneficial effects were apparently reduced (Table 1).

The superior finish on Golden Delicious and Grimes Golden apples obtained with the new fungicide "captan" applied during the summer cover sprays is illustrated in Figures 1 to 4.

The preliminary results presented herewith indicate that captan offers considerable promise as a summer fungicide for russet-sensitive apple varieties. The apparent increase in summer diseases in recent years has necessitated widespread usage of bordeaux mixture as a summer spray with consequent russetting on tender apple varieties. The ability of captan to control summer apple diseases, as reported by Lewis and Shay, together with its beneficial effects on the finish of sensitive varieties suggests a possible solution to the problem of summer disease control on these apple varieties.

PURDUE UNIVERSITY AGRICULTURAL EXPERIMENT STATION, DEPARTMENT OF BOTANY AND PLANT PATHOLOGY, LAFAYETTE, INDIANA

A SPECIES OF GYMNOSPORANGIUM ON QUINCE, PEAR AND HAWTHORN IN ARIZONA

Paul D. Keener

Epiphytotics due to rust fungi (Uredinales) are of sporadic occurrence in Arizona. This is presumably due to the extremely dry atmosphere prevailing throughout most of the year, although certain other conditions, such as temperatures, appear to be favorable for fungus development.

In the higher elevations of the State (particularly on the Mogollon Rim, at 4000 to 6000 ft.) where both winter and summer moisture were favorable during 1951 and 1952, severe outbreaks of a rust belonging to the genus Gymnosporangium occurred. In the central Rim country, at Prescott and in Chino Valley (north of Prescott), quinces were severely attacked. Both leaves and fruits were covered with "aecial horns", the latter so severely as to render them unfit for domestic purposes. On the grounds of the Yavapai County Courthouse at Prescott, every specimen of English hawthorn (Crataegus oxyacantha) was infected with a similar rust (Fig. 1).

At Prescott and at Lakeside (in the eastern Rim country), pears were attacked to a lesser extent than either quince or hawthorn. Fruits were more severely attacked than leaves and in some instances the pears were rendered unfit for human consumption (Fig. 2).

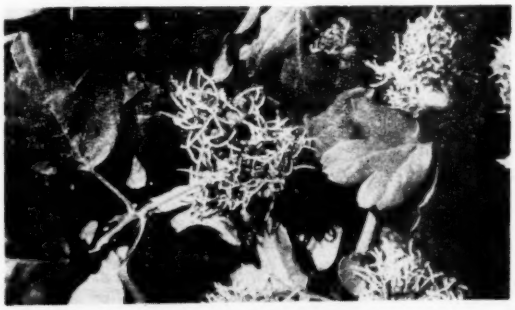

FIGURE 1. Aecial "horns" of Gymnosporangium sp. on fruits of English hawthorn. (Yavapai County Courthouse, Prescott, Arizona.)

FIGURE 2. Aecial stage of a similar rust on pear fruits. Note the complete invasion and distortion of the two fruits. (Lakeside, Arizona, in the eastern Mogollon Rim.)

Several species of Juniperus abound in all of the areas indicated. It is believed that some of these serve as alternate hosts. Further studies are in progress to determine the species of Gymnosporangium responsible for the extreme damage.

DEPARTMENT OF PLANT PATHOLOGY, UNIVERSITY OF ARIZONA, TUCSON

SOURCES OF RED STELE ROOT DISEASE RESISTANCE IN BREEDING STRAWBERRIES IN OREGON[1]

George F. Waldo

The search for strawberry varieties adapted to the State's climatic conditions and market requirements led to the testing of a great many strawberry varieties in the early years of strawberry growing in Oregon. Gardner (3), who tested many varieties, suggested that varieties of western origin should be developed for conditions and market requirements of western Oregon. Following this suggestion strawberry breeding was begun at the Oregon Agricultural Experiment Station in 1920 by C. E. Schuster. Approximately 150,000 seedlings have been grown and fruited since that time.

Varieties known to be adapted to Oregon conditions, such as Marshall, Ettersburg 121, Wilson, and Clark, were used as parents. The vigor of seedlings, as indicated by plant size, where Ettersburg 121 was one parent suggested that Fragaria chiloensis, the native beach strawberry, might be a valuable source of vigor (Table 1). The appearance of Ettersburg 121 indicates that it was derived in part from F. chiloensis. Early in the breeding work, F. chiloensis was used with named varieties in crosses, and the seedlings of such crosses were remarkable for their plant size and vigor. The results indicated that F. chiloensis could be a valuable source of adaptability to Pacific coast conditions. The increased vigor obtained indicated the need for going back to original species as suggested by Crane and Lawrence (1).

During the period 1934-36, a large number of seedlings from many different crosses including those with F. chiloensis as one parent were grown at the Oregon Agricultural Experiment Station. During this period, sizes of plants were determined by measuring the height and the width of single hills. These measurements showed definite differences between size of seedlings where F. chiloensis was one parent and where it was not. A larger percentage of the seedlings from crosses involving F. chiloensis produced large or medium-sized plants than did seedlings that did not have this species as one parent. (Table 1.)

Table 1. Size of plants of seedlings of various strawberry crosses grouped by parents, 1934-36.

Parent groups in cross	Plants measured	Plants of indicated size		
		Small	Medium	Large
	Number	Percent	Percent	Percent
Fragaria chiloensis crossed with varieties	561	7.8	21.4	70.8
Ettersburg 121 crossed with other varieties	716	9.4	45.1	45.5
Fragaria chiloensis hybrids backcrossed to varieties	3,530	22.4	46.9	30.7
Fragaria chiloensis hybrids backcrossed twice to varieties	4,109	19.1	44.6	36.3
Crosses of cultivated varieties exclusive of Blakemore and Ettersburg 121	2,095	34.0	47.1	18.9
Crosses of various varieties and Blakemore	1,703	34.2	57.3	8.5

[1]Approved for publication as Technical Paper No. 772 by the Director of the Oregon Agricultural Experiment Station and the Chief of the Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture. Contribution of the Department of Horticulture of the Oregon Agricultural Experiment Station, and the Division of Fruit and Nut Crops and Diseases.

In 1934-36 definite red stele (Phytophthora fragariae) symptoms had not been recognized on the Oregon Agricultural Experiment Station at Corvallis although it is believed now that the causal fungus was present. The vigor obtained in the F. chiloensis hybrids, however, led to their use in crosses. In 1939 the seedlings were grown in a new location on land which was much heavier and ideal for the spread of the red stele fungus. On this soil red stele developed rapidly. Most of the selections made in earlier years of breeding became infected and were discarded. Some, however, showed much vigor and were evidently red-stele-resistant. Recognition of red stele in other areas in the State revealed the need for red-stele-resistant varieties. Consequently, conscious breeding for red stele resistance became a major objective.

A rapid method for the elimination of red stele-susceptible seedlings seemed desirable so that a larger number of seedlings could be grown and the best parents for red-stele-resistant varieties could be located. Therefore, since 1944 infested soil from the station grounds has been put into greenhouse benches in late July and early August and strawberry seedlings planted during August and September. These seedlings came from crosses made in the greenhouse during the previous February and March. Greenhouse temperature from early November to February was kept as near outdoor temperatures as possible, usually below 50°, but above 32° F. Frequent heavy watering to encourage the spread of the red stele fungus was practiced. In February the seedlings were taken up and examined for red stele. All infected and weak plants were discarded. The vigorous and apparently disease-free plants were "heeled in" in flats and planted in the field during April. Very uniform spread of red stele was noted in the benches, although the amount was not so great in the first tests as in later ones. Probably temperatures were not kept so low and the waterings were not so frequent as in the later years.

About a year after field planting selections were made during the harvest period on the basis of fruit and plant characteristics that indicated commercial value or value in future breeding. Table 2, which indicates the extent of the breeding for red stele resistance since 1944, shows that a relatively small number of selections have been made from over 100,000 seedlings tested. Many crosses producing high percentages of red-stele-resistant seedlings produced none of commercial value; consequently, few or no selections were made.

Table 2. Seedlings tested for red stele resistance in greenhouse benches and resistant and vigorous seedlings planted in the field for fruiting, 1945-52.

Year	Number examined	Saved for field planting	Field selections made
	Number	Percent	Number
1945	9,424	29.4	49
1946	9,561	21.8	50
1947	14,713	14.1	45
1948	16,631	19.4	54
1949	17,537	11.7	53
1950	19,966	19.4	49
1951	10,862	28.8	67
Total	98,694	20.7	367
1952	5,094	33.6	*

*Seedlings planted in 1952; selections to be made in 1953.

Table 3. Crosses giving the largest percentages of vigorous red-stele-resistant seedlings.

Crosses[a]	Seedlings examined	Seedlings saved	Seedlings resistant to red stele	Selections still red-stele-resistant
	Number	Percent	Percent	Number
1817 x F. chiloensis	129	48.1	27.1	1
Aberdeen x 1775	171	45.0	24.6	0
1491 x 1509	405	43.7	28.1	2
Aberdeen x 1787	157	42.7	21.0	0
1775 x 1509	695	40.7	20.8	0
Aberdeen x 1769	113	38.0	23.0	0
1807 x U. S. 3328	615	35.6	20.5	0
1509 x 1876	37	59.5	8.1	0
Aberdeen x 1766	32	46.8	21.9	0
1509 x 1768	151	41.1	27.8	0
1776 x F. chiloensis	145	33.1	0.0	0
1908 x 1509	315	23.5	29.8	0
U. S. 3374 x 1509	301	68.1	23.2	0
Temple x Climax	20	65.0	25.0	0
1768 x F. chiloensis	114	40.4	13.1	0
U. S. 3374 x Temple	54	24.1	5.5	0
1816 x U. S. 3374	1026	22.9	29.3	1
U. S. 3374 x Marshall	198	21.7	24.7	0
Fairland x Md. 683	42	47.7	19.0	0
1980 x 1967	134	43.3	21.6	0
2012 x 1816	845	35.7	20.5	6[b]
1816 x 2012	209	32.1	27.7	1
1937 x U. S. 3378	843	31.9	24.0	0
1974 x Pitt	1001	31.6	13:9	0
1816 x Pitt	230	27.8	29.6	0
Temple x U. S. 3374	69	27.5	21.8	1
1974 x F. chiloensis	484	22.1	27.3	0
2052 x F. ovalis	216	38.4	19.9	2
2012 x F. ovalis	75	46.7	22.7	0
2012 x U. S. 3374	497	40.4	28.4	0
1815 x U. S. 3374	824	35.3	29.2	0
2183 x 1815	476	56.3	24.2	0
2052 x 2181	17	47.1	17.6	0
2253 x 2128	136	55.1	19.9	0
2122 x Marshall	173	50.9	22.5	0
2127 x 2122	256	49.2	29.3	0
1815 x 2100	151	46.4	27.1	0

[a] Numbers without prefixes are selections from the Oregon-U.S. breeding.

[b] Seedlings of this cross were examined for red stele in 1948. Greater numbers of seedlings were examined in 1949 and 1950, but higher percentages of red stele were found. From 4,908 examined, there are now 22 selections red-stele-resistant.

Naturally, vigorous and apparently red-stele-resistant selections already growing in red-stele-infested soil were used as parents. Many of these were the result of earlier hybridizing with F. chiloensis and had been selected for plant vigor as indicated by large size of plant. U.S.D.A. selections known to be red-stele resistant in Maryland, along with varieties known to be resistant in other areas, were also used as parents. Since the ultimate objective in breeding was suitable varieties for freezing and canning, most of the crosses were made to obtain red stele resistance along with canning and freezing quality.

Table 4. Strawberry crosses producing the largest percentages of red-stele-susceptible seedlings when tested in greenhouse benches.

Cross[a]		Seedlings examined	Seedlings discarded for red stele	Seedlings saved for possible resistance to red stele
		Number	Percent	Percent
1629	x 1683	130	88	0
1683	x 1629	161	91	0
1581	x 1574	240	86	0
1890	x 1985	459	84	5
Brightmore	x 1509	1775	84	3
1994	x 2087	149	92	3
1881	x 2001	3902	91	3
1890	x 2001	775	94	1
1967	x 2001	591	93	0
1976	x 1816	202	94	0
2001	x 1967	111	95	0
1937	x 2046	577	96	0
1994	x 1816	799	97	0
1779	x Md. 683	281	78	6
Md. 683	x Midland	233	88	3
2011	x F. ovalis	217	86	0
Marshall	x 2090	819	98	0
2066	x 2201	35	74	9
Magoon	x 2128	34	91	9
Marshall	x Climax	63	97	2
2128	x Climax	251	87	2
Climax	x 2128	143	85	1

[a] All numbers without prefixes refer to Oregon-U.S. selections.

The crosses giving the lowest percentages of red-stele-infected seedlings when grown in greenhouse benches are listed in Table 3. When these crosses are compared with those in Table 4 having the highest percentage of red stele, the sources of red stele resistance are indicated. The following parents of crosses listed in Table 3 seem to be the chief sources of red stele resistance: Aberdeen, Temple, U. S. 3374, Oreg.-U.S. Nos. 1509, 1815, 2012, 2052, and 2122, and F. chiloensis. From Table 3 it appears that resistance may have been obtained also through U. S. 3328, U. S. 3378, Fairland, Md. 683, Pitt, Oreg.-U. S. Nos. 1980 and 2253.

Table 3 shows that few selections were made in the field from the crosses giving the greatest percentages of red-stele-resistant seedlings. Resistant varieties and U.S.D.A. selections did not prove directly valuable as parents for commercial uses. Among the weaknesses noted were susceptibility to mildew (Sphaerotheca) and lack of fruit quality and production. Many of the selections made in the first years of breeding later showed susceptibility to red stele and have been discarded.

There are now about 75 selections considered red-stele-resistant, the parentages of which are listed in Table 5. More than half of these selections are from three crosses, the most important of which is Oreg.-U. S. 2012 x Oreg.-U. S. 1816. At present this cross appears to be the best for pomological value and red-stele resistance. Some of the selections represented by the crosses listed in Table 5 are being used in breeding though they probably have no direct commercial value. In this table, the crosses are classified into three groups according to the sources of red-stele resistance as follows: F. chiloensis only; F. chiloensis plus Aberdeen and CC-18; and CC-18 and Aberdeen only. These represent the original parents of the selections or varieties listed that appear to be the source of red stele resistance. All other original parents were known to be red-stele-susceptible.

Table 5. Seventy-five red-stele-resistant selections classified as to probable source of resistance. (All numbers without prefixes refer to Oregon-U.S.D.A. selections).

Probable source of resistance	Cross		Number of selections
Fragaria chiloensis	1491	x 1509	2
	1779	x 1815	1
	1815	x 1776	2
	1815	x 1639	11
	1815	x Donner	4
	1816	x 2012	1
	1817	x *F. chiloensis*	1
	1967	x 1815	1
	2012	x 1816	22
	2012	x Brightmore	1
	2012	x Donner	2
	2052	x *F. ovalis*	2
Total			50
F. chiloensis, Aberdeen, and CC-18	1815	x 2136	10
	1816	x U. S. 3374	1
	1974	x U. S. 3374	1
	2012	x 2138	1
	2136	x 1815	2
	2136	x 2001	5
	U. S. 3378	x *F. chiloensis*	2
Total			22
CC-18 and Aberdeen only	Temple	x U. S. 3374	1
	1994	x U. S. 3374	1
	Northwest	x U. S. 3374	1
Total			3
Grand total			75

An analysis of the original parents of these selections was made on the following basis: listing each selection's parents, adding the percentage of each parent of all selections, and finally calculating the percentage for each parent. The results of the analysis follow:

	Percent		Percent
Dorsett, Fairfax, and Narcissa	33.2	Miscellaneous	7.1
Ettersburg 121 and other Etter selections	16.4	Clark	5.7
Marshall (Oregon)	8.7	CC-18 (Scottish sel.)	5.1
Blakemore	8.2	Aberdeen	4.3
Fragaria chiloensis	7.9	*Fragaria ovalis*	3.4
			100.0

Dorsett, Fairfax, and Narcissa have been used so extensively in breeding that they make up about one-third of the original parents. Ettersburg 121 and other Etter selections were also used extensively as sources of vigor. Marshall, Blakemore, and Clark were extensively used in the earlier breeding but, because of susceptibility to virus diseases as well as to red stele, many of their progeny have been discarded. Because of their vigor, many selections going

back to F. chiloensis and F. ovalis have been retained. Selections going back to the Scottish selection CC-18 and to Aberdeen have been used to give red stele resistance in the more recent crosses.

When red stele became evident in the new location on heavy soil, certain selections later found to be very resistant to red stele were growing vigorously. These selections were Oreg.-U. S. Nos. 1491, 1509, 1815, and 1817. These were extensively used along with selections derived from Aberdeen or CC-18 as parents in crosses for red-stele-resistant varieties.

A study of the parentage of the Oregon selections used as parents indicates that the most important source of red-stele resistance must have been F. chiloensis, since all the other parents were known to be red-stele-susceptible. The parents of Oreg.-U. S. 1491 can be traced to U. S. 836 (Progressive x F. chiloensis). Since Progressive is evidently red-stele-susceptible, red-stele resistance seems to have come from this selection of F. chiloensis, obtained from Ambato, Ecuador. Oreg.-U. S. 1815 has also been very resistant to red stele and a good parent for red-stele-resistant varieties. It traces back to Oreg.-U. S. 1490, a sister seedling of Oreg.-U. S. 1491. Oreg.-U. S. 1509 seems to derive its resistance to red stele from an unnumbered selection of F. chiloensis and Marshall. Red-stele resistance in Oreg.-U. S. 1817 is also traced to a selection of the same parentage. The strain of F. chiloensis used came from the Oregon coast. By growing seedlings in red-stele-infested soil, the genes for resistance have been maintained through several generations from these parents.

Further evidence that red-stele resistance comes from F. chiloensis has been obtained by growing selections of this species from the Oregon coast in red-stele-infested soil. One selection from Waldport showed no infection of red stele for six consecutive years, 1943 to 1948. Other selections tested have shown very little infection. Attempts are being made to determine whether F. ovalis, the native meadow strawberry of the West, may also be a source of red-stele resistance.

Many varieties and selections from crosses were tested in greenhouse benches for resistance to red stele. These tests were made to determine resistance to the particular race or races of the red stele fungus present in the soil at Corvallis. Only a relatively few varieties, Aberdeen, Pitt, Temple, Md. 683, Fairland, U. S. 3328, U. S. 3374, U. S. 3378, and Wash. 181, were found resistant. Most of these red-stele-resistant varieties have been used as parent material. Varieties susceptible in the Oregon tests include the following: Brightmore, Brune's Marvel, Climax, Corvallis, Cupertino, Daybreak, Donner, Dorsett, Ettersburg 80, Ettersburg 121, Fairpeake, Klondike, Konvoy, Lassen, Maytime, Marshall, Midland, Northwest, President, Redheart, Redwing, Robinson, Shasta, Sierra, Sioux, Sparkle, Tahoe, Wickson, and Wray Red. Climax, a red-stele-resistant variety as well as the leading variety in Scotland, was found susceptible here. It has been used in crosses, and seedlings from crosses of it with susceptible selections were not resistant. Sparkle, considered resistant to one race in the eastern States, was also susceptible here.

Discussion

Fragaria chiloensis of the Pacific coast has given progeny of remarkable vigor when crossed with standard varieties. This hybrid vigor has been maintained through the process of selection in further crossing. First- and second-generation seedlings, however, were not of commercial value. Further crossing and rigid selection of seedlings resulted in selections appearing to have commercial value. It is not known whether the original F. chiloensis selections used in this line of breeding to give resistance were red-stele-resistant. However, by selection for vigor, red-stele resistance has been obtained and maintained through several generations. It is possible that genes for red-stele resistance may be associated with genes for vigor or inherited in the same manner. Several F. chiloensis selections have been tested in infested soil, but the selection from Waldport, Oregon, is the only one which has shown no red stele symptoms at any time.

Evidence of loss or breakdown of resistance as observed by Reid (2) has been noted. Where it has occurred, however, it has been due to the appearance of another race of the red stele fungus. Some selections considered red-stele-resistant have a few roots with steles partially destroyed by the red stele fungus but no roots entirely killed. Selections derived in part from F. chiloensis showing some susceptibility to red stele have often shown remarkable vigor. It has been noted that the portions of the root system not entirely killed by red stele put out new roots rapidly in spring after temperatures became favorable for quick growth. In fertile soil and with ample moisture, these selections grow as rapidly as fully resistant selections. Selections with this characteristic have not been considered in this study, although they have been

used in breeding and many are listed in Tables 3 and 4.

Red-stele resistance seems to have come from the immediate parent that was red-stele-resistant. No clear evidence of resistance has appeared in crosses of susceptible parents derived from resistant parents.

Observations of the last ten years of breeding for red stele resistance lead to the conclusion that resistance is a matter of degree. Possibly rapid growth of the causal fungus within the conducting tissue of the root as well as age and condition of the roots is a factor. Efforts have been made in these tests to have environmental factors as favorable as possible for the growth of the fungus into the roots.

A chief weakness in the present line of breeding at the Oregon Agricultural Experiment Station has been the prevalence of small size of berry. When well grown, however, many of these selections produce berries of good average size. Further crossing of the present selections with selections and varieties of larger berry size is now being carried on.

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MYCELIAL MATS OF OAK WILT FOUND IN MINNESOTA DURING DRY WEATHER[1]

Robert N. Campbell and David W. French

Mycelial mats of Endoconidiophora fagacearum Bretz were found in Minnesota after a two and one-half months' drought in 1952 on oak trees killed by wilt. This observation is noteworthy because it has been indicated that humid conditions, such as rainy weather, are prerequisite to mat formation (1, 2). Morris and Fergus (3) also point out that moisture is important.

The mats were found on November 14 on many standing red oak trees which had been killed during the summer of 1952. They were in all stages of development, from newly-formed and heavily sporulating to completely decomposed and overrun by secondary fungi. The odor characteristic of the wilt fungus was very pronounced in the vicinity. Squirrels had gnawed the gelatinous center portion as well as part of the surrounding mycelium of many of the mats. The mats on three trees had abundant perithecia. Cultures producing typical endoconidia were obtained from the mats and from the ascospores at the tips of these perithecia.

According to Weather Bureau records, only 0.43 inches of rain fell from September 1 to November 15 in the area where the mats were found. This is 4.8 inches below normal. Killing frosts occurred October 5 and October 16 to 21. After October 21, the weather remained warm, with average temperatures ranging from 30° to 57° F., which was 4.4° above normal.

Apparently these mats developed after the end of the growing season and during a prolonged drouth, indicating that there is enough moisture under the bark of standing dead trees to permit fungus development in very dry weather. It is also apparent that there is a reservoir of inoculum by which the fungus may be transmitted even after the growing season is over, if trees can be infected at that time.

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MINNESOTA AGRICULTURAL EXPERIMENT STATION

[1]Paper No. 2967, Scientific Journal Series, Minnesota Agricultural Experiment Station.

PROGRESS OF OAK WILT INVESTIGATIONS IN OHIO

H. C. Young, Geo. J. Bart, Oren Spilker, W. H. Brandt, and R. B. Redett

Survey

During the summer of 1952 the Division of Forestry of the Department of Natural Resources surveyed 85 of the 88 counties in the State. The three counties not surveyed were Champaign, Clark, and Madison, and the reason was that there were no aerial-photo maps for them. The survey was made at a height of 1500 feet and widths of 2 miles. Each plane carried a pilot and an observer and when a suspected center was noted, the place was recircled until it was definitely marked on the map. Following this, the centers were investigated by ground crews and identifications made. The results showed that oak wilt occurred in 55 of the counties, or a total of 562 positive centers. The greatest concentration of centers occurred in Pike, Ross, Scioto, Adams, Jackson, Vinton, and Coshocton Counties.

Following the survey, the ground crews not only attempted to confirm centers, but also made every effort to have all diseased trees removed. In most cases, land owners cooperated especially well and while at this time no definite statement can be made as to the final results, it is assumed that a great many of the centers have been removed. It is the plan to recheck many of these centers, particularly as soon as foliage appears in the spring, and to eradicate all remaining diseased trees and to determine further spread. In some cases in the eradication procedure poisoning of trees was done, but not to any great extent. The general procedure will be to salvage all trees for lumber or wood products as rapidly as they become diseased.

Research Phase

The work, started January, 1952, was divided into three parts: (1) the testing of all possible host plants for the oak wilt fungus, the establishment of nurseries where inoculation work can be done, outside and in the greenhouse, and the testing of several antibiotics; (2) determination of the longevity of Chalara in all parts of a diseased tree after cutting (this includes all size twigs, stump, roots, and lumber); and (3) the determination of the wood-rotting ability of Chalara and associated fungi. This latter was supported directly by grant from the National Oak Wilt Committee.

(1) Inoculation of Chalara into the following species of plants: ash, sour gum, chestnut, black cherry, walnut, locust, dogwood, beech, elm, maple, poplar (Lombard), sassafras, redbud, hickory, wild grapes, currants, blackberries, and poison ivy. Inoculations were made at five different times throughout the summer and fall. Wilting and discoloration of the foliage appeared in chestnut, but none of the other inoculated species showed symptoms typical of oak wilt. Two or three of these species showed a type of symptom that will have to be checked further next season. All the inoculated plants will be studied for longevity of the fungus, even though it is not causing disease.

Antibiotics: Results were inconclusive owing to insufficient number and size of trees. The work will continue this winter and next year. Antibiotics being tested are: Actidione, Thiolutin, Rimocidin, Chloromycetin, Potassium Penicillin, and Procaine Penicillin.

(2) Longevity tests: The life of the fungus was studied in large black, red, and white oak and under many different environmental conditions. Diseased trees were felled and cut into lumber. Samples were taken from the lumber, the slabs, medium and small twigs, leaves, and from roots of various sizes. From the very outset, at no time could Chalara be isolated from lumber or sawdust, even immediately after cutting. Four weeks after cutting the organism could not be isolated from any portion of the above-ground parts of the tree. It was possible to isolate Chalara from roots adjacent to the stump and for as far as 6 to 8 feet from the stump. When root sections 20 feet in length were taken up, it was impossible to isolate the organism except from sections about 6 feet adjacent to the stump. In all of this work the moisture content of the various parts was determined.

While these results are based on one year's work, it would seem that there is little likelihood of the fungus spreading from felled dead trees or from lumber or any wood product after they become dried.

(3) The other phase worked upon was the effect of associated wood-rotting fungi. The

fungi studied were those contaminants frequently isolated or recovered from specimens of wood from trees infected with oak wilt. In all, about 15 such isolates were studied. For this study wood blocks of red, black, and white oak, 3/4 x 1/4 x 3 inches long, were used. These blocks were suspended in test tubes, or not quite allowed to touch the media on which the various fungi were growing. The experiment was carried in an incubator for a period of four months. The results were as follows: Chalara alone had very little effect on reducing the strength or the weight of the blocks; culture isolate #19 reduced static-bending strength of the blocks 90 percent in the four-month period; isolates #9 and #43, identified as Xylaria multiplex, decomposed wood but no more rapidly whether the blocks were previously inoculated with Chalara or not. In all of the work, Chalara did not seem to predispose a block to increased rotting by any other type of fungi.

Another interesting sidelight that came from this work was that a few of the fungi, and particularly Xylaria multiplex, completely prevented the growth of Chalara on agar plates. Several of the isolates had less effect.

It would seem advisable to recommend from these results that trees should be cut promptly and, if so, will yield as good lumber as though they had not been attacked by oak wilt.

Other Phases

An extensive phase of the project has been an attempt to find an insect vector that might be responsible for the general spread of the disease. This has been thought especially important since in Ohio root grafting has not been found to be a very important factor. Many important leads on the insect vector are being investigated, but to date no definite results are available.

Another phase of the Ohio work is an attempt to determine methods of silvicultural procedure to keep a woodlot continuously producing lumber even though the disease is present. One of the most heavily infected woodlots in the State forms a part of this plan of culture. It is believed that by proper cutting and sanitation a woodlot can be made to produce year after year even though oak wilt might be prevalent.

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THE PYCNIAL STAGE OF CRONARTIUM FILAMENTOSUM

Frank G. Hawksworth

Cronartium filamentosum Hedgc. is a native rust and an important pathogen of ponderosa pine (Pinus ponderosa var. scopulorum Engelm.) in many parts of the Southwestern and Intermountain regions. In a comprehensive article on the etiology, distribution, and importance of this rust, Mielke[1] has stated that he did not observe pycnia in nature, although he mentioned that Weir[2], in an unpublished report, "found that pycnia developed on inoculated pines."

In June 1952, pycnial drops were observed to be commonly associated with aecia of this rust on ponderosa pine on the South Rim in Grand Canyon National Park, Arizona. Over thirty aecia-bearing trees ranging from saplings five feet high up to veterans over two feet in diameter were examined and pycnial drops were found in every one. They were very abundant in all trees but one. Subsequent observations at the Fort Valley Experimental Forest, Flagstaff, Arizona, and at Bryce Canyon National Park, Utah, showed that the pycnial stage was present on infected pines at these localities also, although it was not so common as at Grand Canyon. Just why the pycnial stage was prominent in 1952 and why it was not found in previous years presents an interesting question. Presumably local weather conditions might be a determining factor in the production of pycnia. Weather records for Grand Canyon show that the first half of 1952 was nearly normal in most respects, although precipitation during March and April was more than twice the normal amount.

The sweetish pycnial drops are amber colored and measure from 1 to 2 mm. in diameter. The larger drops were usually found on the larger twigs. The pycnial drops darken and shrink on drying but no pycnial scars, such as have been described for Cronartium ribicola, were noted. Cross-sections of infected twigs reveal typical sub-peridial pycnia. The pycnospores are hyaline, spherical, and measure 1.5 to 2 microns in diameter. Weir's[3] pycnospore description is similar except for size, which he lists as 2.8 x 3 microns. The slender pycnophores measure 30 to 40 microns in length and average about 1.5 microns in width. Most of the pycnial drops were distal to the current year's aecia, although a few were noted in a proximal position. Pycnial drops, in some cases, were found up to 10 inches or more beyond the current year's aecia; this is seemingly indicative of the annual rate of spread of the rust mycelium along a branch as the pycnia are presumed to precede aecia by one year.

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[3] See footnote 2.

FOMES ANNOSUS (FR.) CKE. IN CONIFEROUS PLANTATIONS IN NEW YORK STATE

D. S. Welch and E. L. Stone

The fungus Fomes annosus (Fr.) Cke. is reported to occur throughout the North Temperate Zone and to be common as a saprophyte in North America (1). It is said to be occasional on the wood of coniferous trees in New York State (4) but specific records of its occurrence there in coniferous plantations appear to be lacking.

Typical sporophores of Fomes annosus were found on the roots of a windthrown tree in a 34-year-old plantation of Pinus resinosa Ait. on an acid soil near Ithaca, New York. The planting was done in 1914 and the first thinning was made 29 years after planting. The fungus was discovered five years after the first thinning. The sporophores were attached to the roots and were almost invisible from above, being located in the cavity caused by the uprooting. A photograph, as shown in Figure 1, was obtained of the fungus in situ by using a mirror to bring the image within focusing range of the camera without disturbing the natural arrangement of the roots and fungus fruiting-bodies. The identity of the fungus was verified by cultures obtained from tissue plantings from a sporophore. Typical conidia described as characteristic of this fungus appeared in the cultures.

FIGURE 1. Fomes annosus sporophores in natural position on roots of Pinus resinosa. View from below, photographed with aid of of a mirror. One root has been cut to permit better view. (Photograph by W. R. Fisher.)

Dying of trees was observed in a 29-year-old plantation of Pinus resinosa on a well-drained acid soil near Golden's Bridge, Westchester County, New York. The area of dead and dying trees covered about one-tenth acre and the trees on the periphery were in a dying condition. When roots one-eighth to one-half inch in diameter from the dying and adjacent trees were excavated and examined, small resinous lesions were found. Cultures from these yielded Fomes annosus and were comparable to those obtained as noted above.

The root and butt rot disease associated with Fomes annosus has long been recognized as a serious problem in Europe, especially in artificial stands (5, 6). Early reports (2, 3, 7, 8) indicate that similar behavior may be expected in this country as our plantations become older and are subjected to thinnings.

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A HALF CENTURY OF PLANT PATHOLOGY IN THE SOUTH[1]

George F. Weber[2]

This paper is a discussion of the development of Plant Pathology in the South during the past half century. The real meaning and true facts concerning progress cannot be stated effectively without reference to the position of the science in the area at the dawn of the twentieth century and earlier.

Probably the first noteworthy records of plant diseases in the South appeared about 1850, when the Virginia fruit growers complained about losses of their orchards. Fire blight [Erwinia amylovora] of pears, which we now know to have been the cause, practically destroyed these plantings before Burrill had shown for the first time that plant-parasitic bacteria existed. The growers explained their troubles by some of the casuistic and contradictory theories of the ancients. In Virginia the extensive grape growing industry also had disappeared because of the downy mildew disease [Plasmopara viticola] almost before the demonstration of Bordeaux mixture by Millardet. In Georgia the plantation owners were aware of plant diseases and were even treating wheat seed with copper sulfate as early as 1850, presumably for the control of smut [Tilletia spp.], as had been advocated by Prévost some 50 years earlier. This was before the publication of De Bary's thesis wherein he reported proof of the actual establishment of a fungus parasite in a living plant.

These records are examples among many of the serious consideration given to plant diseases at this early time. In Georgia Speth and Starnes were recording observations on diseases, and Quaintance was studying fruit diseases. In Virginia Alwood started experiments on the control of rust and scab of apple [Gymnosporangium sp., Venturia inaequalis] and of peach, pear, and grape diseases. Sufficient progress had been made to promulgate crop protection laws. This activity was almost paralleled in the neighboring State of Maryland, where Johnson and Townsend were studying asparagus rust [Puccinia asparagi], peach yellows [virus], and sweetpotato diseases, and where laws and regulations were advocated for the suppression of plant diseases.

Scattered records are plentiful enough to indicate that southern growers were up-to-date on the meager information on plant diseases available before 1885. There is no doubt that this alertness was an important factor in the founding of the various Agricultural Experiment Stations in the individual States and of the Department of Agriculture in Washington as well.

From 1885 to 1888 a large number of the Southern States established experiment stations for the basic purpose of finding answers to the ever increasing number of questions arising from the production of crop plants. Within a few years a laboratory for the study of plant diseases was set up by Atkinson, who was making considerable headway in the study of cotton diseases in Alabama, to be followed by Stedman and Earle dealing with diseases of cotton and vegetables and with fungicidal controls. In North Carolina McCarthy, who had been studying grape and peach diseases, also established a plant pathological laboratory. Herrick in Mississippi was advocating certain controls for important plant troubles, including a quarantine for crown gall [Agrobacterium tumefaciens].

During the last decade of the nineteenth century some attention was given to plant diseases in almost every State. Contributors to knowledge were usually members of the newly established station staffs, under the title, however, of Botanist, Horticulturist, Agriculturist, Biologist, or Entomologist. There were no plant pathologists as such listed on any station staff.

Apple rust [Gymnosporangium], an important disease recognized at this time, was being studied by Trelease in Arkansas, Anderson in South Carolina, and Alwood in Virginia, all of whom, as well as Scribner in Tennessee and Bogue in Oklahoma, were also interested in grape diseases, particularly downy mildew which was apparently widespread and destructive and had almost defied control.

Earle in Alabama, Jennings in Texas, and Hume in Florida had issued provisional lists of the fungus floras of their respective States at this early time. Although none of these lists was

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[1]Prepared in connection with the Golden Anniversary meeting of the Southern Agricultural Workers, at New Orleans, February 1953. Because of its general interest to plant pathologists the Survey requested permission to publish this historical account in the Reporter.

[2]Professor of Plant Pathology, College of Agriculture, University of Florida, Gainesville.

complete they are indicative of the stage of development of knowledge and of the preoccupation with fungi and the plant diseases that they cause. Attention was given to vegetable diseases in most of the Southern States. Study of the root-knot nematode [Meloidogyne spp.] was in progress in Texas, Alabama, and Florida. These States, together with Maryland, Louisiana, and Georgia, were also concerned with sweetpotato diseases, especially soft rot [Rhizopus]and black rot [Endoconidiophora fimbriata], which were apparently highly destructive to this crop, a staple food for this area.

The solanaceous crop plants, potatoes, tomatoes, and tobacco, were given attention everywhere. Hopkins and Rane in West Virginia were studying potato scab [Streptomyces scabies] and early blight [Alternaria solani]. Rolfs of Florida, Johnson of Maryland, and Bain in Tennessee were most interested in tomato diseases. The causal organism [Sclerotium rolfsii] of a new blight disease described by Rolfs on tomato is still very destructive to its numerous hosts and remains largely uncontrolled. Particular emphasis was concentrated on special crops by certain state experiment stations before 1900, among them being sugarcane and rice in Louisiana, oranges and grapefruit in Florida, and wheat in West Virginia, Kentucky, Georgia, and Oklahoma. In wheat, smut was the most important disease to be controlled. The citrus diseases, scab and melanose [Sphaceloma (Sporotrichum) citri, Phomopsis citri], in Florida were described and control measures advocated. In Kentucky, Garman had described broomrape [Orobanche, a phanerogam] and had experimented with fungicides and studied smuts. Wilcox in Oklahoma had finished his study of the rhizomorphic root rot fungus [Clitocybe] at about the close of the decade.

In summary, it is evident that the status of knowledge, interest, and accomplishments of southern growers and scientists in the field of plant pathology and plant disease control was pretty much abreast of the times. Discoveries made in various parts of the world were immediately siezed upon and put into practice in the South. Seed was being treated before the germ theory of plant disease causation was generally understood. Within a year or two of Millardet's conclusive experiments on the preparation and use of Bordeaux mixture, the fungicide was in general use by many grape growers of the South.

The new century raised the curtain on an era of experimentation undreamed of heretofore. The agricultural public was convinced that scientific methods to reduce the extensive losses suffered from plant diseases could be developed. These losses often amounted to complete destruction of crops, as with the pear and grape growing industries of Virginia, mentioned earlier. The establishment of the state experiment stations was a great step forward, although an adjustment period of a decade or more intervened during which leadership, finances, and personnel were the important factors in success. Usually, where leadership was good practical discoveries resulted sooner and more often. Because of limited finances, however, the best leaders went from the South to other parts of the country, consequently progress was slower than it might otherwise have been.

In order to survey more carefully the development and accomplishments of the botanists, horticulturists, and plant pathologists in the various States since 1900, it seems desirable to consider each State's contributions and the respective contributors separately. Accordingly, the fifteen States of the South will be considered in alphabetical order.

Among the contributions of individual States are the cooperative achievements with the U. S. Department of Agriculture. Some of the more important of these are the tobacco disease control program under Clayton, phony peach studies under Hutchins, vegetable disease resistance work by Andrus, and more recently the disease forecasting studies by Miller and Person. Other activities appear scattered through the following account.

In a brief paper the most that can be done is to indicate the foundations, trend, and pace of progress. It is not possible to do justice to all of the individual endeavor that took part in advancing knowledge about plant diseases in the South during the last 50 years. In particular, much of the crowded and rapid achievement of recent years must be omitted.

Alabama

Work inaugurated by Mell and continued by Atkinson was resumed in 1901 by Wilcox, who during the next eight years published reports on diseases of fruits, particularly stone fruits, and vegetables. In 1911, Wolf began his service at the station and during the next five years reported his findings concerning diseases of a wide range of host plants. Probably a study of peanut leaf spot [Cercospora personata] was his principal accomplishment. He did some work on citrus canker [Xanthomonas citri], to which his successor Peltier devoted almost full time for the next four years. For the next ten years most contributions were made to knowledge of

diseases of pecans, sweetpotatoes, and leguminous plants. In 1929, Seal joined the staff and was later made head of the department.

Arkansas

Through the influence of the early studies of Trelease, on apple rust, pear blight, and grape downy mildew, the department was set up about 1906 and its work was inaugurated by Hewitt, who pioneered for the next decade in the study of apple measles [still undetermined, confused] and of straight head of rice [non-parasitic]. He was succeeded by Elliott, who was interested in diseases of cotton and particularly in their control, and early advocated the sulfuric acid delinting method for angular leaf spot [Xanthomonas malvacearum] control. Elliott published on Ascochyta blight [A. gossypii] and other diseases of cotton, tomato wilt [Fusarium oxysporum f. lycopersici], and sweetpotato black rot. Rosen joined the staff in 1918; he has dealt with bacterial diseases of plants and with the improvement of resistance of cereals, especially oats, to rusts and other diseases. Young succeeded Elliott and has devoted his research largely to cotton wilt and deficiency diseases. More recently, Tullis and Cralley have made extensive contributions to our knowledge of rice diseases.

Florida

Until 1905, all the investigation on plant diseases was done by botanists. Fawcett was the first pathologist as such in the State. All his time was given to the study of citrus diseases. He was succeeded by Stevens and Burger, who worked on citrus canker and other important citrus diseases, followed later by Rhoads, Ruehle, and Suit in succession. Current contributions concern certain virus diseases of citrus and the prevention of decay in transit and storage. Burger presented new information on cucurbit diseases. Sherbakoff studied vegetable diseases, primarily buckeye rot [Phytophthora parasitica (P. terrestris)] of tomatoes and wilt of solanaceous plants. Tisdale preserved the shade tobacco industry of the State by developing varieties resistant to black shank [Phytophthora parasitica var. nicotianae]. Weber selected successfully for resistance in tomatoes to nailhead spot [Alternaria tomato] and contributed extensively to knowledge of vegetable crop diseases in the South, such as web blight of beans [Rhizoctonia microsclerotia], angular leaf spot of cucumbers [Pseudomonas lachrymans], and gray spot of tomatoes [Stemphylium solani]. Walker bred wilt-resistant watermelons and safeguarded the highly productive Florida lands that were rapidly becoming infested with the fungus [Fusarium oxysporum f. niveum]. Camp and Bryan led in the study of deficiency diseases of citrus. Eddins did pioneer work on ring rot [Corynebacterium sepedonicum], seedpiece decay, and control of late blight [Phytophthora infestans], of potato, and showed that potato brown rot [Xanthomonas solanacearum] could be controlled by regulating the soil reaction. Kincaid developed methods for controlling downy mildew [Peronospora tabacina] of tobacco and Decker produced an eggplant superior to market varieties and resistant to the tipover disease [Phomopsis vexans]. Many other plant pathologists have added just as important items to the Florida list.

Georgia

Personnel changes handicapped the progress of plant pathological research prior to 1913, when Higgins joined the staff of the experiment station. Starnes studied plum diseases but concluded that the disease problem was too much of a handicap for the industry to overcome. In spite of his efforts and those of many others plum growing failed and scattered commercial orchards were abandoned. Stuckey and Temple demonstrated the cause of and recommended control for the blossom-end rot [non-parasitic] of tomatoes. Results from Higgins' studies on seed treatment for disease control and the resultant stimulus to similar work in other institutions constitute probably the most valuable contribution to plant pathology made from the Georgia station. Root rot diseases of cotton occupied attention from 1923 for the next decade. It was found that seed treatment with organic mercury compounds gave excellent control in sterilized soil and some control in fungus-infested fields. The results were so convincing that a majority of cotton growers adopted seed treatment. The production of tomato seedlings encountered several disease problems, such as bacterial spot [Xanthomonas vesicatoria] and early blight. Recommendations for seed disinfection, a spray program, and revised handling procedures more than assured the growers of successful production. Recent work includes studies on the newly recognized disease of cotton due to meadow nematodes [Pratylenchus], a

thorough re-study of bean root-rot diseases, investigations on peanut disease, and an extensive program of breeding for disease resistance. No discussion of the progress of the solution of Georgia plant disease problems could be complete without mentioning Orton, Rands, Hutchins, Neal, Boyd, and Weimer, each of whom made significant contributions. In recent years phony disease [virus] of peach has been studied by KenKnight, who followed Hutchins at the Fort Valley Station. Gaines has made significant progress in tobacco disease work at Tifton, in the control of downy mildew and the root-knot nematode.

Kentucky

Garman, a botanist by title, had been the principal contributor in the field of plant pathology prior to 1900 and continued so for almost two decades thereafter, acquiring information concerning fungicides and their application along with many other lines of activity. He studied the effect of pathogenic bacteria and investigated the role of bacteria in nitrogen nodule formation. Seed-borne pathogens were of particular interest to him, particularly in corn and bean. Observations were made on carnation root rot, strawberry diseases, tree diseases, and the troubles that were manifesting themselves in regard to nursery stock. McFarland was interested in ergot [Claviceps] and in the mycological aspects of applied botany. Valleau started work in Kentucky about 1920 and concentrated on the tobacco diseases, ably assisted by Johnson and later by Diachun. The early work was largely general, with special emphasis on the bacterial diseases. Later attention was focused on virus diseases, and extensive emphasis has been given to this particular field; with application to the surrounding tobacco-growing States as well. True tobacco mosaic, mild mosaic, ring spot, and other virus diseases have been carefully dealt with, along with means of identification, methods of transmission, and recommendations for control.

Louisiana

Research in plant pathology in Louisiana practically had its beginning when Adams Fund money became available. In 1906, Fulton was appointed as the first plant pathologist. In 1908, he was succeeded by Edgerton, who was in charge of the research in botany and plant pathology for 42 years until his retirement in June 1950, when he was succeeded by Chilton. Diseases of the major crops such as sugarcane, cotton, rice, vegetable crops, and strawberries have received most attention.

The sugar industry in Louisiana has depended largely on the control of red rot [Colletotrichum falcatum], root rot [Pythium spp.], and mosaic [virus]. Special mention should be made of the great impetus given to disease studies by the failure of Louisiana sugarcane crops from 1924 to 1926, caused by red rot and mosaic. Some of the resistant P. O. J. canes were introduced soon after this time, and in the early 1930's the first C. P. canes were introduced. In 1950 a breeding station was set up on Grand Isle. The first cane seedlings ever produced in Louisiana were grown here in 1951. During the long period from 1906 to the present time, much valuable information has been obtained in regard to the developmental cycles of the different diseases.

An intensive study of the factors responsible for the boll rots of cotton resulted in a bulletin which was used as a reference in most cotton-producing countries for many years.

The finding that the bean anthracnose disease [Colletotrichum lindemuthianum] would not develop during periods when the temperature was relatively high was applied to the production of disease-free seed. Early attempts to produce wilt-resistant tomato varieties by hybridization and selection were successful. It was found that seedlings of susceptible varieties grown in sterilized soil reinfested with the wilt fungus [Fusarium] die very quickly, or at least show evident signs of the presence of the disease, which made it possible to select for wilt resistance and to discard the susceptible plants in the seed bed. Person found that the marketing losses of sweetpotatoes due to black rot and to soil rot [Streptomyces ipomoea] could be very materially reduced by dipping the roots in a borax solution in the packing house immediately after washing; also that soil rot could be largely eliminated by soil treatment with sulfur.

The strawberry leaf diseases have been controlled by frequent applications of Bordeaux mixture. Much information has been obtained in regard to the diseases of other crops such as oats, rice, figs, onions, pears, dewberries, citrus, and various ornamentals, and control measures have been found for many of them. Plakidas, Tims, Ryker and others made important contributions. Methods were worked out for eradicating the black scale or anthracnose [Colletotrichum lilii] from Easter lily bulbs, and for the control of the pear leaf spot [Fabraea

maculata] and dewberry rosette [Cercosporella rubi] with sprays.

Chilton and his students discovered that a large percentage of the soil Actinomycetes produce antibiotic substances, and that the antibiotic-producing species are more abundant in what are considered to be the better soils. Genetic studies on certain fungi, particularly Glomerella, have produced information on mutation and other types of variation which has a very direct bearing on the origin of new parasitic strains or races.

Alligator weed [Alternanthera phylloxeroides] is a serious pest in sugarcane fields, but was very quickly brought under control with 2,4-D. This was one of the first instances of control of a weed with this chemical.

Maryland

Johnson had extensive experimental work on asparagus rust in progress at Maryland as early as the beginning of the new century. The disease was very common and exceedingly destructive. Attention was also given to a general fungicidal spray program for the protection of peaches. Other activities included experiments dealing with the development and control of sweetpotato diseases. Spray programs for the control of celery blight were investigated. Following Johnson, Norton continued the early projects, particularly the revision of the fruit spray program, and the development of fungicides for other crops. Rose mildew [Sphaerotheca] and tomato diseases were high on the priority list and considerable experimentation was done on these plants along with many ornamental and vegetable crops. Heuberger continued the fruit spray program while at Maryland. Cox has been interested in and obtaining results with seed- and soil-borne organisms that cause seedling diseases and loss of crop plants, such as the Fusarium wilts. Research with the downy mildews has yielded noteworthy results and is being continued.

Mississippi

Plant pathology was first taught in Mississippi State College in 1908. Of the crops produced in the State most work has been done on the diseases of cotton, citrus, sugarcane, sweetpotato, pasture grasses, and to a lesser extent truck crops.

The first person to study plant diseases and make recommendations for their control was Herrick, who experimented with a fungicidal spray program. He was also interested in methods of controlling oat smut [Ustilago], potato scab, pear blight, and Fusarium wilt of tomatoes. He identified hundreds of specimens of plant diseases and wrote as many letters recommending control measures. He called attention to the need for a quarantine against crown gall of fruit trees.

Hibbard made contributions to a better knowledge of bacterial plant pathogens, including pear blight, and a few years later Beal, Neal, and Miles were prominent in the plant pathology program of the State, working on crown rust [Puccinia coronata] of oats, root knot of peach, and mosaic of sugarcane. They also carried on extensive experiments in the control of pecan scab [Cladosporium effusum], which was becoming destructive, cabbage yellows [Fusarium oxysporum f. conglutinans], recently introduced, and gladiolus scab [Pseudomonas marginata]. Recent activities include a continuing study of the anthracnose diseases caused by Colletotrichum spp. on cereals, grasses, and many leguminous crop plants.

They did yeoman work in the eradication of citrus canker and of sugarcane mosaic.

Neal's work on the diseases of cotton and their control is well known and important, particularly his research on Fusarium wilt and soreshin [Rhizoctonia]. Wallace contributed to our knowledge of sweetpotato mosaic [virus suspected] and cotton anthracnose [Glomerella gossypii], while Wedgeworth studied oak leaf blister [Taphrina caerulescens], tomato diseases, and brown rot of stone fruits [Monilinia fructicola]. Beal was outstanding for his lectures in elementary plant pathology and for teaching of advanced students. Miles was actively interested in studying the seedling diseases of cotton and varietal resistance to Fusarium wilt and to the root-knot nematode. He discovered Verticillium wilt of cotton and the downy mildew [Sclerospora macrospora] of oats, and continued, with the help of others, studies on diseases of sweetpotato, tomato, and ornamentals, and their control.

In recent years the plant pathology staff has been built up and an aggressive research program is under way.

North Carolina

In 1903, Stevens, who had previously been serving as professor of biology in the College, greatly extended the experimental work in plant pathology and soil bacteriology. His co-operative studies with Orton on watermelon wilt resulted in the development of a resistant variety named the Conqueror. During his tenure the following tasks were undertaken: control of grape and apple diseases, study of the efficiency of pure culture inoculation for legumes, investigation of chrysanthemum ray blight [Ascochyta chrysanthemi], experiments on the formalin treatment of oats, and studies on corn mold, on the Fusarium causing cowpea wilt, on the diseases of certain grasses and of clover, and on the wilt of okra and cotton [Fusarium oxysporum f. vasinfectum]. A number of the major lines of investigation begun by Stevens were continued under Fulton.

Wolf, who succeeded Fulton, studied wildfire [Pseudomonas tabaci], of tobacco, a new disease discovered in the State for the first time in 1917. He also gave attention to clover stem rot (Sclerotinia trifoliorum) and soybean diseases. Notable improvements in plant bacteriological techniques were devised by Wolf and his associates.

Lehman succeeded Wolf in the position of Plant Pathologist. He came in 1915 as instructor in botany and during the 37 years of his service has published a total of more than 60 papers covering a range of subjects from watermelon, peanuts, tobacco, and cotton, to soybeans and certain other minor crops.

Poole assumed the leadership of plant pathological work in 1926. Major studies included the diseases of sweetpotatoes, particularly scurf [Monilochaetes infuscans], black rot, and nematodes, peach diseases and arsenical injury to peaches, and diseases of white potatoes, dewberries, and other less important crops. Shaw made substantial advances in methods of controlling diseases of tobacco, peaches, and peanuts. Smith's work accelerated breeding for resistance to Granville wilt [Xanthomonas solanacearum] in tobacco and culminated in the development of resistant Oxford 26.

The more important accomplishments in recent years by Jensen and his co-workers include the release of the tobacco varieties Dixie Bright 101 and 102, resistant to both Granville wilt and black shank, and the control of downy mildew of cucurbits [Pseudoperonospora cubensis] and of tobacco. Hepting and associates have studied mimosa wilt [Fusarium], little leaf of pine [undetermined], white pine blister rust [Cronartium ribicola] and other tree diseases at the U. S. Department of Agriculture Division of Forest Pathology laboratory at Asheville.

Oklahoma

The early work of Wilcox and Bogue included studies on cereal smuts and downy mildew and other diseases of grapes, with some attention to cotton and vegetables. In 1915 Rolfs became head. His main research, on bacterial blight or angular leaf spot of cotton, resulted in methods of seed treatment for control. Chester followed Rolfs. His studies on the epidemiology of wheat leaf rust [Puccinia rubigo-vera var. tritici] led to the initiation of annual leaf rust forecasts. His monograph "The Cereal Rusts" summarizes knowledge concerning the leaf rusts of cereals. He also studied bacterial blight of cotton and its control by acid delinting of seed. Ray made outstanding contributions concerning bacterial blight of cotton, cotton seed treatments, and the control of pecan scab. McLaughlin conducted important fundamental investigations of corn root diseases. Significant work was done by Hoffmaster on sorghum diseases. Other staff members have been occupied in more recent years with cotton diseases, rust-resistant wheat, sweetpotato nematodes, pecan scab, and diseases of grasses.

South Carolina

Anderson apparently was a botanist with great mental elasticity -- a characteristic commonly found among the early successful agricultural workers -- since he devoted himself comprehensively and productively to a wide range of interests. From the mycological viewpoint he produced an instructive and inclusive report on fungi and bacteria, with regard to their various characteristics and the manner of distinguishing them. He conducted extensive experiments on the selection and constant improvement of the general fungicidal spray program for the protection of fruit trees and ornamentals. He also acquired new information on the identification and control of the downy and powdery mildews and the many kinds of cereal rusts as well as asparagus rust.

Newman was interested in fungous diseases of cotton and in the control of peach diseases, primarily brown rot and the various virus diseases. Rolfs also gave considerable attention to cotton diseases, mostly the bacterial disease. Other research topics were the diseases of cereals and many of the leguminous crop plants, and spray programs for the protection of fruit trees.

Armstrong and Karrer added a great deal to our knowledge of Fusarium wilt diseases of southern crops. Barre published on anthracnose and other cotton diseases. Arndt worked mainly with seed treatment of cotton and other crops. Andrus at the U. S. Department of Agriculture Regional Laboratory at Charleston developed watermelon varieties resistant to Fusarium wilt and anthracnose [Colletotrichum lagenarium]. Moore, Clayton, and Epps made important contributions to the epidemiology and control of vegetable diseases. Nusbaum discovered and described the internal cork virus disease of sweetpotato. Graham's investigations have greatly increased our understanding of little-known but important nematode diseases of tobacco and other crops.

Tennessee

Bain was Professor of Botany at the University of Tennessee and Plant Pathologist of the Experiment Station until his death in 1919. His accomplishments were varied, as he had an active research mind and a general appreciation of biology. He pioneered in plant disease resistance, with his most outstanding work resulting in anthracnose-resistant [Colletotrichum trifolii] red clover. As a student of plant physiology he made several contributions to knowledge on the action of fungicides, notably the effect of copper on peach leaves. Closely associated with Bain for the early part of his career was Essary, who published jointly with Bain on some aspects of the red clover anthracnose work. Later Essary recognized tomato Fusarium wilt as a disease that could be controlled by resistance and actually released the first resistant lines.

Hesler succeeded Bain. He came to Tennessee in 1919 and was engaged in active teaching until 1943. Although his principal contribution to plant pathology was made through classroom instruction, he has published two books and 66 papers, on mycology and pathology.

Sherbakoff began a study of wheat diseases and of Fusarium wilt of tomato and cotton in 1920. The genus Fusarium had received his especial attention in previous years and he became concerned with studies of wilt diseases in general and of breeding for disease resistance. His outstanding contributions were studies on the taxonomy of the Fusaria.

Andes, who joined the organization in 1925, for a number of years was mainly engaged in fruit disease investigations and fungicide studies. Felix recognized several new plant diseases of economic importance to the State, made contributions to fungicide application, and is currently breeding blight and rot-resistant tomatoes and disease-resistant strawberries.

Texas

The first work of interest in Texas, following the contributions of Jennings, was the comprehensive experimental fungicide trials of Sanborn. For a decade this work was most outstanding and was highly productive in results and adaptability. Paddock's studies aided and expanded the program materially. In 1919 Taubenhaus started extensive experiments on the control of sweetpotato diseases, obtaining results that are still the basis for general recommendations. He described anew several diseases of sweetpotatoes previously poorly understood. Later he worked with watermelon wilt and cotton boll rot, as well as diseases of cereals. His work was voluminous and of such calibre as to attract the attention of his co-workers in other States. He is credited with hundred of publications, including articles, bulletins, and books.

Dunlap served as head of plant pathology for some years until recently when Watkins succeeded him. Noteworthy contributions by members of the staff include tomato disease studies by Young and Harrison, and nematode and citrus disease studies by Godfrey. Texas root rot [Phymatotrichum omnivorum] engaged the attention of Ezekiel and Rogers over a number of years.

Virginia

Studies on the life history and epidemiology of the cedar rust of apples resulted in the passage of the Cedar Rust Law, designed to control this destructive disease by compulsory eradication of red cedar trees in the vicinity of apple orchards.

Fruit-disease research by Schneiderhan and Groves resulted in many valuable contributions to knowledge on apple scab, bitter rot [Glomerella cingulata], and other diseases.

Wildfire and angular leaf spot [Pseudomonas angulata] of tobacco appeared in Virginia in 1918 and caused very severe losses for several years until research eventually brought them under control. Henderson developed good commercial varieties of tobacco of different types with resistance to mosaic [virus] and black root rot [Thielaviopsis]. Shear's studies on the physiological diseases of tobacco commonly known as frenching and mature leaf breakdown greatly increased understanding of the nature of these troubles. Jenkins has devoted the greater part of his time to studies on meadow nematode and black shank of tobacco. New strains of tobacco with resistance to black shank were released in 1947.

Smith's nematode-resistant strains of alfalfa are being tested in infested areas and some of them show considerable promise.

Vegetable disease research by Fromme included among other topics the development of cabbage resistant to yellows [Fusarium] and studies on bean and cowpea rusts [Uromyces phaseoli, var. typica and var. vignae]. Wingard developed rust-resistant varieties of snap beans, carried out experiments on club root of cabbage [Plasmodiophora brassicae], and studied yeast-spot [Nematospora phaseoli] of lima bean, bacterial soft rot of tomato, and the control of the various leaf blights and fruit rots of tomatoes. McWhorter's studies concerned the treatment of beet seed for the control of seedling diseases, the Fusarium wilt and early blight diseases of tomatoes, and diseases of certain ornamentals, especially of narcissus and poppy. Cook published the first extensive papers on the powdery mildew [Erysiphe polygoni] of snap beans and methods for its control, and on vegetable seed treatment. The Hawkesburg wilt-resistant watermelon also was a result of his work.

West Virginia

The systematic study of plant diseases at this Station may be said to have been initiated by Sheldon, later Bacteriologist for the Station during the years 1903 to 1907. He was perhaps the first person to hold that title in the United States. Among other accomplishments he found that the anthracnose of watermelons was a serious disease and that the fungus from watermelon would infect cucumber, gourd and muskmelon, but not squash nor pumpkin.

Giddings' investigations on potato spraying, which were begun in 1909 and continued for several years, resulted in general establishment of spraying for control of potato diseases. Giddings also did pioneer research on dusting vs. spraying as a means of applying fungicides.

Giddings and Berg's practical demonstrations of the relation of the rust galls on red cedars to the apple rust played an important role in settling law suits against the State for cutting out red cedars in proximity to apple orchards. During his work on rust resistance in the red cedar, Berg found and propagated an immune tree. Proof that a tomato strain of Phytophthora infestans existed was also obtained by Berg. His studies of apple measles led to the conclusion that more than one disease was involved in the "measles complex".

Sherwood's methodical approach to the practical control of orchard diseases and insect pests remains a standard of excellence in the opinion of fruit growers.

Notable early contributions by Leonian dealt with variability in the genera Phytophthora and Fusarium. The extensive work on the physiology of the fungi started by Leonian, and continued by Barnett and Lilly is among the principal contributions made by almost a score of workers of the department under the leadership of Orton and later of Leach.

Experimental work on control of cherry leaf spot [Coccomyces hiemalis] demonstrated the severe cumulative injury caused by this disease. The revised spray program based on this research has saved the cherry industry of the State. The nature, cause, and method of spread of purple-top wilt [aster yellows virus] of potatoes was determined and it was demonstrated that the disease could be successfully combatted by controlling the aster leaf hopper with DDT.

Summary and Conclusion

In summary, it has been shown that the observation and study of plant diseases in the southern part of the United States began with the earliest settlers. They were unable, however, to do very much about the effects of plant diseases until research showed that many theories of the past were without foundation. The current era in plant disease control had its beginning with the completion of De Bary's stem rust study in 1853. His monumental discoveries were followed by Pasteur's demonstration that the belief in spontaneous generation of life was a fallacy. Koch in 1875 demonstrated artificial culture methods for bacteria and fungi and Millardet discovered bordeaux mixture in 1882. These fundamental discoveries were widely disseminated and eagerly followed up by trials and experiments of various kinds during the next two decades. During this time also state experiment stations were founded and scientifically trained workers began to produce experimental results, although full-fledged plant pathologists, as such, did not exist in this region until the early years of 1900. The development of experimental work was rapid and the results were good. Contributions of the South during the first half of the twentieth century to the science of plant pathology, and the resulting benefits arising from plant disease control, are many and important. Outstanding and unique is the achievement of complete eradication of citrus canker, a bacterial disease of citrus that had spread to five States. Acquistion of knowledge on nutritional deficiency diseases is entirely confined to this period and is of first importance in plant growth and crop production. The cedar-apple rust eradication control laws resulted from long and accurate experimental work.

Naturally, of first importance in the South is the study of diseases of field crops especially adapted to the South, such as sugarcane, cotton, sweetpotato, peanut, watermelon, tung, and tobacco. Most of the present voluminous amount of data on diseases of these crops originated in the South. Also important were the experiments concerned with the control of diseases of fruit crops such as apple, peach, citrus, and fig. Problems of the vegetable-producing sections were studied and results kept pace with those for other crops. In recent decades seedling diseases, nematodes, and the study of both old and new fungicides, have received special emphasis. Probably fungicides are used more in the South than elsewhere and the contributions of southern workers in this field are comparable to those of any other area today.

The writer wishes to express his appreciation to the many correspondents and co-workers who have aided in the accumulation of the contents of this paper and in the verification of assembled data.

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UNUSUAL RECORDS AND OTHER BRIEF NOTES ON PLANT DISEASES

PHORADENDRON JUNIPERINUM, A NEW HOST FOR UREDO PHORADENDRI

By Frank G. Hawksworth

The rust Uredo phoradendri Jackson was first described from Oregon[1], pp. 285-286 where it was found on the oak mistletoe, Phoradendron villosum Nutt. The rust has also been recorded on the long-spiked mistletoe, P. longispicum Trel., in northern California[2], p. 391. The uredial is the only spore stage known.

In June 1952, Uredo phoradendri[3] was found on the juniper mistletoe, Phoradendron juniperinum Engelm., on Utah juniper, Juniperus osteosperma (Torr.) Little, near Jacob Lake, Kaibab National Forest, Arizona. A second collection of the rust was made in January 1953 on the same species of mistletoe growing on one-seed juniper, J. monosperma (Engelm.) Sarg., in the Sandia Mountains near Albuquerque, New Mexico. These are apparently the first records of it from the Southwest.

The uredia of the rust on P. juniperinum occur in localized areas on the shoots, which are girdled and killed beyond the point of infection. The rust was not common at either the Arizona or the New Mexico locality.

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[1]Jackson, H.S. 1918. The Uredinales of Oregon. Brooklyn Bot. Gard. Mem. 1:198-297.
[2]Arthur, J.C. 1934. Manual of the Rusts in United States and Canada, 438 pp.
[3]Identified by Dr. George B. Cummins, Purdue Agricultural Experiment Station, Layayette, Indiana.

OCCURRENCE OF ARBORVITAE BLIGHT IN TENNESSEE

By H. E. Reed

During the winter of 1952 specimens of ornamental arborvitae, Thuja orientalis var. conspicua Berckmans, in various stages of degeneration (Fig. 1), were brought to this laboratory. After careful examination and a review of the literature, the malady was diagnosed as arborvitae blight caused by Cercospora thujina Plakidas.

FIGURE 1. Specimens of Arborvitae showing various stages of blight.

Symptoms of the disease were essentially in agreement with those described by Plakidas[1, 2] in Louisiana. They consist of a general "thinning out" of the shrubs caused by a killing of the small branchlets which first turn reddish-brown and later fall off, giving a "ragged" or "unhealthy" appearance. Cankers were present on the young stems. These girdle the bark and kill the young twigs. Tufts of sporophores and spores fitting the description of Cercospora thujina as described by Plakidas were obtained when diseased stems and leaf scales were kept in a moist chamber for 48 hours.

The disease spreads rapidly in the nursery, usually killing the shrubs in two to three years. However, plants are usually unsalable after one season. In the garden individual shrubs may remain in an unhelathy condition indefinitely.

Over 30,000 plants were affected in the nursery that submitted the specimens. It was suggested to the nurseryman that he apply basic copper sulfate (Tennessee Copper Co. "Tri-basic", 53% Cu) at the rate of 4 pounds in 100 gallons of water in early September and again in late October, using a good spreader sticker in the spray solution. Recent information from the grower is that, following applications as recommended, the disease was completely cleared up last season, even in severely affected cases. Diseased specimens kept as checks here at Knoxville show further degeneration due to spreading of the disease.

The disease has been reported in Mississippi, Arkansas, Texas, and Louisiana by Plakidas[2], where he has estimated its probable occurrence for 27 to 33 years. Prior to 1952, however, the disease was not recognized as such in Tennessee. Although degeneration of arborvitae has been a problem to nurserymen for many years, it has in the past been attributed to insects and unfavorable environment. There is a strong possibility that in many instances arborvitae blight is the real cause. Thus the production of healthy shrubs appears to be relatively easy in view of the simple known control measures.

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[1]Plakidas, A.G. 1943. Arborvitae blight. Phytopath. 33:1117.
[2]Plakidas, A.G. 1945. Blight of oriental arborvitae. Phytopath. 35:181-190.

A BETTER DRESSING FOR THE TREATMENT OF PRUNING WOUNDS

By Pinchas Tamir

I have spent several months in California and Arkansas observing orchard and nursery practices under the International Farm Youth Exchange program. Among other observations I noted that at the present time there is no satisfactory dressing for the treatment of pruning wounds. This observation agrees with the statement of Marshall[1], "None of the materials now in use appears to be capable of accomplishing both of these objectives [Favouring callus growth and protecting wood] under the various conditions imposed." Various asphalt-dressings (like "Tree Seal", are used extensively in California orchards and nurseries, but in many cases they proved to be injurious rather than beneficial. "Applied in very thick coatings, asphalt not only frequently causes blistering, but appears in many cases to stimulate decay rather than retard it," claims Marshall[1].

The advantages and disadvantages of most of the wound dressings under use in different countries are summarized by Tamir[2].

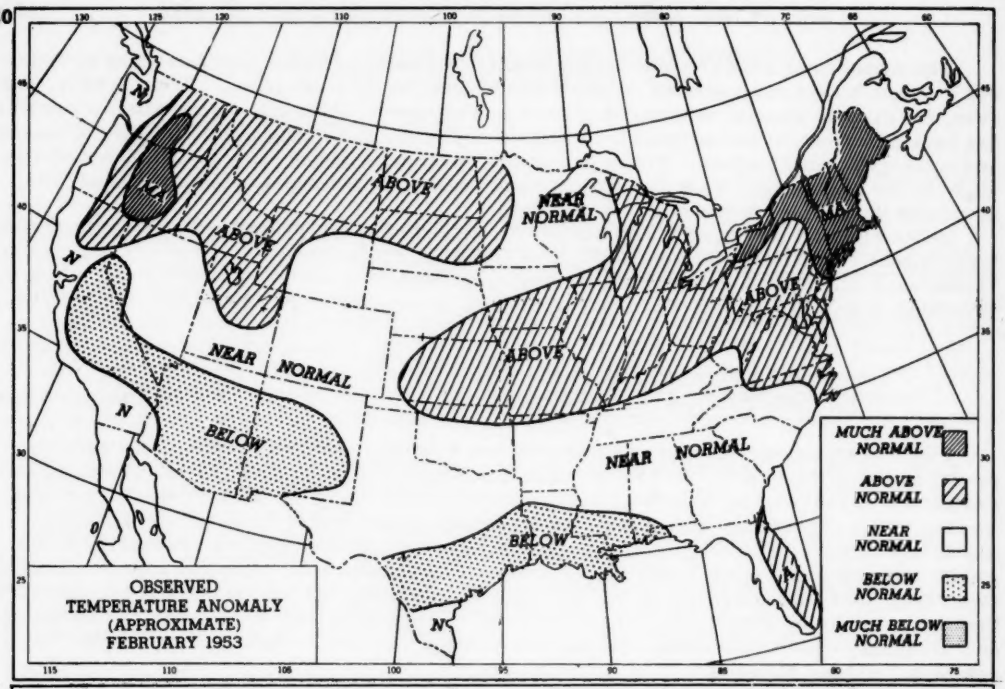
A home made paste has been used in Israel for several years very successfully. It is called Sheged (which presents the Hebrew abbreviations of oil, lime and beeswax) and made by melting one pound of beeswax with one pound of motor oil (like "Shell 20") and then pouring one pound of commercial lime powder, mixing it with the melted substances to form a uniform mixture. After cooling the paste is ready for use. It is yellow in color, very flexible, and easy to apply by finger. If it is too hard, heat again and add oil. If it is too soft, heat again and add lime.

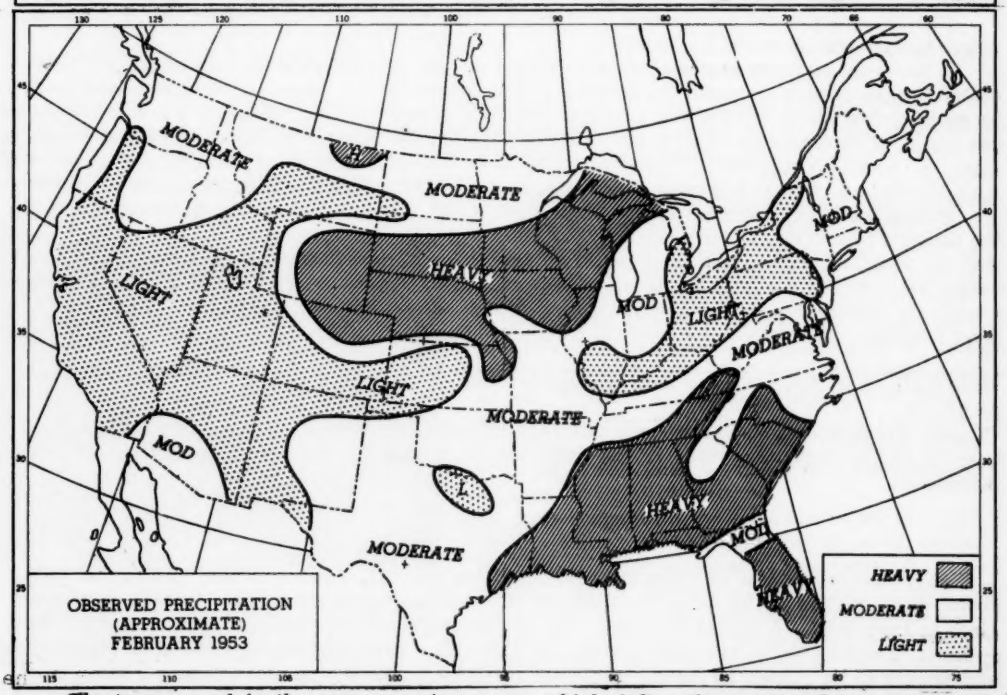
Preliminary experiments conducted by Dr. R. M. Samish (a lecturer in Horticulture in the Hebrew University of Jerusalem, College of Agriculture, Rehovoth) and the writer[2] indicate that the addition of growth substances, like 2, 4-D, or other substances (possibly hormone activating substances) like zinc oxide may accelerate the healing process and at the same time induce a bactericidal and fungicidal effect. There is also some evidence that Sheged might serve as a good grafting wax as well as a mixture for preparing budding tape, both for deciduous and citrus.

[1]Marshall, R.P. 1950. Care of damaged shade trees. U.S. Dept. Agr. Farmers' Bull. No. 1896, pp. 16-19.
[2]Tamir, Pinchas. 1951. The effect of different dressings on the healing of pruning wounds of deciduous trees (A thesis presented to the Hebrew University of Jerusalem, College of Agriculture, Rehovoth, in Hebrew).

A CORRECTION

That part of the note in Plant Disease Reporter 35: 411, 1951 entitled "Variegated Sida rhombifolia in Central America" relative to this species not being a host of Abutilon mosaic virus is incorrect. A mosaic disease of S. rhombifolia was proven to be graft transmissible by L. O. Kunkel (Phytopath. (Abstracts) 20: 129-130. 1930) and variegation in S. rhombifolia was proven to be caused by Abutilon mosaic virus by K. Silberschmidt (Arquivos Inst. Biol. (São Paulo) 14: 105-156. 1943). Apologies are extended to these workers for this oversight. -- H. H. Thornberry, University of Illinois, Urbana.





The terms used in the accompanying maps, which define the ranges of temperature and precipitation, are numerical class limits. These are based on a statistical analysis of past records through which is determined the normal frequency of occurrence of temperatures and precipitation at various times of the year for different locations. For temperature the classes above, below, and near normal are so defined that they each normally occur one-fourth of the time; much above and much below normal, one-eighth of the time. Precipitation is depicted in terms of light, moderate, and heavy, each class normally occurring one-third of the time and thereby having equal probability of occurrence. These maps graphically represent only the general trends and give the country's weather picture at a glance. For quantitative studies, where monthly mean temperatures and actual precipitation records are needed for a given time and place, other publications of the Weather Bureau should be consulted. P. R. M.

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